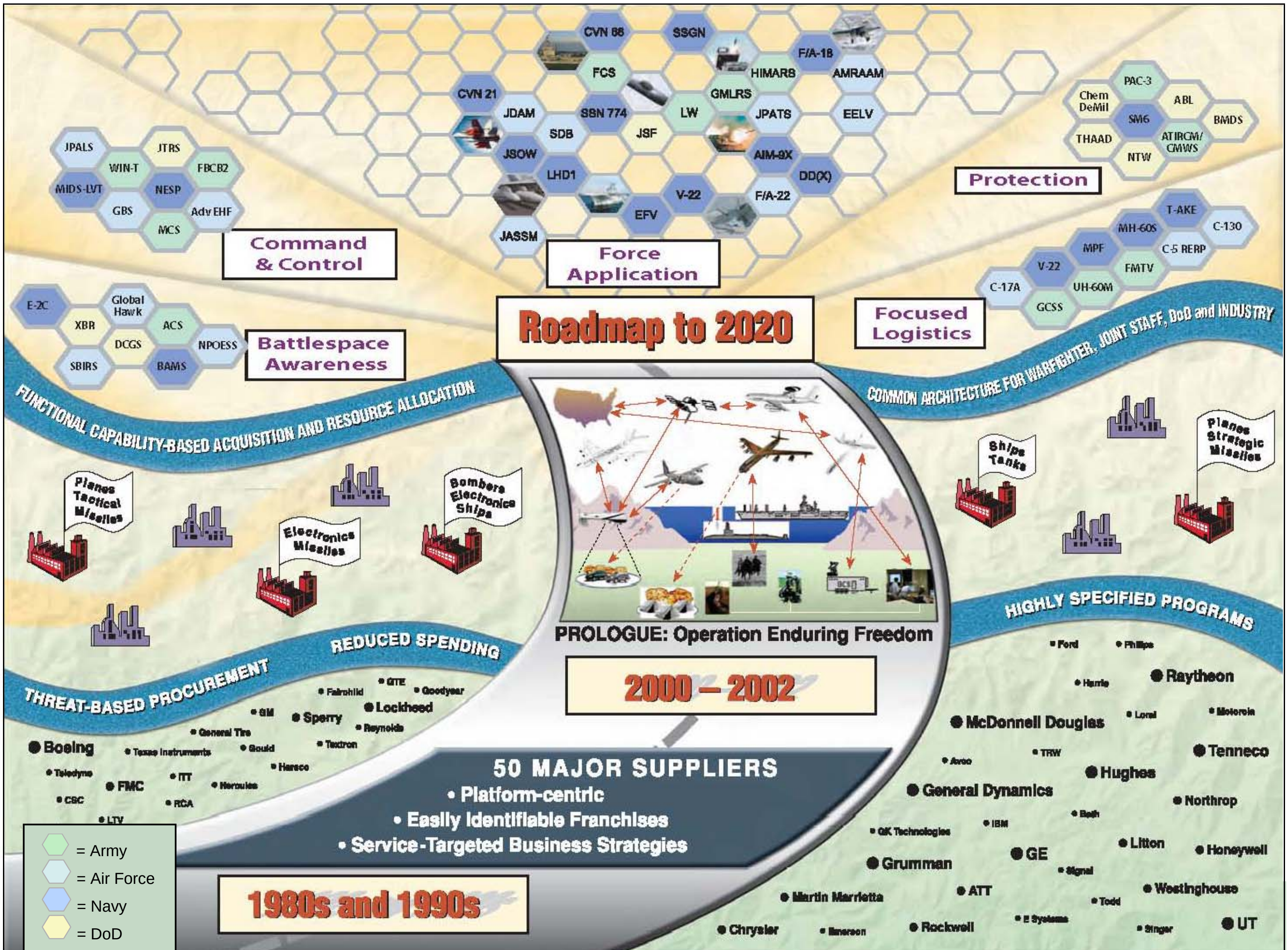

DEFENSE INDUSTRIAL BASE CAPABILITIES STUDY: FORCE APPLICATION

OCTOBER 2004

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A version of the cover graphic was used in *Transforming the Defense Industrial Base: A Roadmap* (ODUSD(IP), February 2003). This earlier study concluded that the Secretary's transformation mandate required a different lens for viewing the defense enterprise—one organized around the most essential operational effects that the U.S. warfighter must be able to deliver to be successful. The Joint Staff has now reorganized around new functional concepts. The top of the landscape shows the joint functional concepts where materiel solutions play a major role: Battlespace Awareness, Command and Control, Force Application, Protection, and Focused Logistics, with representative programs indicated for each. Other functional concepts, such as Network Centric Operations, are being developed. These functional concepts, along with related joint operating and integrating concepts, are becoming the central theme for Department decision-making. We will continue to adjust our industrial base capability assessments to reflect evolving Department concepts as appropriate.

This move to capabilities-based decision-making will fundamentally change the defense enterprise. How the Department looks at what it has and what it needs also will affect who participates in the defense industrial base—and likely will cause it to expand. Capabilities-based decision-making provides a common and comprehensive vernacular to the operators, the acquirers, and industry. Clearer communication and an integrated vision should continue to improve the efficiency of planning, decision-making, and execution.

This report and all appendices can be viewed online and downloaded at:

http://www.acq.osd.mil/ip

This report was produced for the Under Secretary of Defense (Acquisition, Technology, & Logistics) by the Deputy Under Secretary of Defense (Industrial Policy) from May - October 2004. Stephen Thompson led this effort; Dawn Vehmeier, Michael Caccuitto, Dawana Branch, and Robert Read also had major roles in the production of this report. Support was provided by Booz Allen Hamilton, Inc. (BAH), the Institute for Defense Analyses (IDA), and First Equity Development, Inc. Among others, special thanks are due to John Williams and Carmen Alatorre-Martin of BAH, and Jim Woolsey and Emile Ettedgui of IDA for their important contributions. The team would like to acknowledge the contributions of the Study's Red Teams, consisting of 21 individuals, who reviewed this report. Companies listed or mentioned in this report are representative and not exhaustive. Inclusion or exclusion in the report does not imply future business opportunities with, or endorsement by, the Department.

Inquiries regarding the report should be directed to Mr. Stephen Thompson at (703) 697-0051 or (703) 602-4331. Certain suppliers of which we were not aware may possess technologies that mitigate identified industrial base insufficiencies. Such suppliers should contact Mr. Thompson so that we can document those capabilities for future use. Appendix I provides a form with which such technologies can be brought to the attention of this office.

DEFENSE INDUSTRIAL BASE CAPABILITIES STUDY: FORCE APPLICATION

OFFICE OF THE DEPUTY UNDER SECRETARY OF DEFENSE
(INDUSTRIAL POLICY)

OCTOBER 2004

DEFENSE INDUSTRIAL BASE CAPABILITIES STUDY (DIBCS) SERIES STUDY OBJECTIVES

Develop a capabilities-based industrial framework and analytical methodology as a foundation for programmatic and investment decision-making.

Identify technology critical to enabling the new Joint Staff functional warfighting capabilities. Establish a reference database of key industrial base capabilities mapped to warfighting functional capabilities.

Conduct industrial base capability assessments on priority critical technologies to identify deficiencies.

Develop a systematic method to craft industrial base strategies to remedy industrial base deficiencies identified; and encourage proactive, innovative management of the industrial base.

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Findings

Defense industrial base assessments must be linked to warfighting capabilities and assessed in a capabilities-based context. This report deploys a methodology used to link warfighting capabilities to industrial base capabilities. Using the Joint Staff's Joint Force Application Functional Concept (JFAFC), we identified 1,036 capabilities that directly enable American warfighting leadership in this area. To enable these capabilities, 212 technologies qualified as ones in which the United States should be ahead of any potential adversary. Of these 212 technologies, we assessed industrial base sufficiency for 32 priority critical technologies. We found that, with few exceptions, available industrial base capabilities for these technologies are sufficiently innovative and robust. We developed remedial strategies for the six technologies where we believe sufficiency can be assured only with active implementation of policy measures.

- During the course of this study, we identified technologies that are not likely to be part of the U.S. warfighting arsenal. They are important because they represent unusual technical solutions and could pose challenges to U.S. warfighters if proliferated elsewhere. We have created a "Watch List" to formally identify these technologies for further consideration and policy remedies. Other technologies with similar potential impacts may become apparent in our future assessments and will be added to this ongoing "Watch List."

- Based on our work to date, we have found that acquisition policies that govern program manager behavior and program strategies provide program managers the requisite flexibility to effectively manage their programs within functional capability constructs.

- At the Department level, much work has been accomplished to conduct program oversight in contexts relating to mission capabilities, roadmaps, and associated architectures. However, the Department is not yet reviewing programs in the full joint functional capability context. Without this more comprehensive acquisition oversight, industry will not likely be motivated to systematically develop synergistic, cross-platform solutions in a functional capabilities context. Accordingly, we have developed a blueprint for such a functional capabilities acquisition oversight process.

- We also continue to be concerned that production-ready technologies have limited on-ramps to ongoing programs. We first treated these transitional issues when we did case studies of 24 emerging defense suppliers in late 2002. We have re-visited a number of these companies and have realized that such innovations can be sidelined as a result of many factors: program managers' budgetary constraints; technologies not envisioned in original program requirements; kernels of innovation embedded in losing contract bids; or other technologies not completely aligned with current requirements, like those on our "Watch List." The Industrial Base Investment Fund has evolved from our previous Innovation Clearinghouse concepts. It would be a Congressionally-funded instrument managed at the most senior acquisition level of the Department, designed to promote insertion of such producible technologies into programs of record.

- We continue to use the Defense Industrial Base Capabilities Study (DIBCS) assessments to develop and deploy the policies and processes necessary to promote the health of the industrial base available to warfighters in the 21st century.

Recommendations

1) The Department should implement the remedies in this report to address the six industrial base issues identified in the Force Application area, and should continue to monitor the two “Watch List” items.

2) The Department should reinforce acquisition policies that empower program managers to flexibly and effectively manage programs within functional capability constructs. At the same time, individual program managers’ decisions must not be allowed to—unintentionally—harm the industrial base.

3) The Department should continue to expand the capabilities-based lens of program oversight, which now convenes single-program Defense Acquisition Board (DAB) meetings, or capability area reviews based on mission-oriented roadmaps or architectures—none as comprehensive as the functional capability construct. The Program Managers’ Functional Capability Conference (PMFCC) and the associated Capability Area Review (CAR) concept, prototyped in June 2004, should be further validated in a series of five successive prototyping exercises for Command and Control, Force Application, Protection, Focused Logistics, and Battlespace Awareness. The utility of this process should be demonstrated as soon as feasible to provide a broader capability-based decision-making construct for the Under Secretary of Defense (Acquisition, Technology, and Logistics).

4) The Department should establish the Industrial Base Investment Fund to provide better on-ramps for production-ready technologies nominated by emerging innovative suppliers and by company or Department program managers.

5) Within the Department, ODUSD(IP) should continue to be the clearinghouse for strengthening the industrial base. ODUSD(IP) will further assess Force Application industrial base sufficiency using the capabilities framework, databases, and policy tools of the DIBCS process. This framework will also be used for industrial base capabilities assessments for Protection and Focused Logistics, as it has been for Battlespace Awareness and Command and Control.

FOREWORD

Defense Industrial Base Capabilities Study: Force Application (DIBCS FA) is the third of a five-part series which assesses the ability of the industrial base to produce the technologies and components most critical for 21st century American warfare, as defined by the Joint Staff's functional concepts.[1] The first two studies in this series, on Battlespace Awareness and Command and Control, were published in January and June 2004, respectively.[2] Studies on Protection and Focused Logistics will follow by May 2005.

The cover page being used for this series originated in our study *Transforming the Defense Industrial Base: A Roadmap* published in February 2003. It depicts the consolidation of the defense industrial base from over 50 major suppliers in the 1980s and 1990s to only five major suppliers by 2000. It also captures the watershed in the Department's thinking about warfighting capabilities as a result of the Global War on Terrorism, which illustrates major tenets of the Secretary's transformation mandate. Finally, it represents our commitment to provide emerging defense suppliers a map into the defense enterprise. We do this by translating warfighting capabilities into the technology and industrial base vernacular familiar to industry.

The first three reports in this industrial base capabilities study series refute the concerns of those bemoaning the excesses of the consolidation of the 1980s and the 1990s. In fact, our research has changed our views about the size and composition of the industrial base available to the Department. The studies on Battlespace Awareness and Command and Control identified nearly 500 companies and research institutions making contributions to those capabilities; 281 companies and research institutions are involved in the challenges of Force Application—further illustrating that the industrial base available to the Department has not become too consolidated.

Indeed, the ability of the Department to effectively source from the broadest industrial base available for warfighting capabilities—and not just the traditional *defense* industrial base—will enhance the innovation available to future warfighters. For example, Command and Control warfighting capabilities increasingly will be provided by the commercial information technology industrial base. There are numerous examples of companies not traditionally associated with defense making invaluable contributions to Force Application as well. Some companies, like iRobot and Aerovironment, were originally featured as case studies in our *Transforming the Defense Industrial Base: A Roadmap* study—and have become increasingly important players in the defense enterprise. But for many others, their defense businesses have continued to languish. Of the 24 case study companies from our original study,[3] we revisited eight as part of

[1] See Chairman of the Joint Chiefs of Staff's Joint Capabilities and Integration Development System (JCIDS), CJCSI 3170.01D (February 2004), specifically the functional concepts—Battlespace Awareness, Command and Control, Force Application, Protection, Focused Logistics—where we assessed materiel, industrial base capabilities to be most relevant.
[2] These reports can be viewed online and downloaded at http://www.acq.osd.mil/ip.
[3] See Appendix B of *Transforming the Defense Industrial Base: A Roadmap*, February 2003, for detailed case studies of these 24 companies.

our work on Force Application. Generally, these companies have grown substantially in the last two years: employment has grown on average from 55 to 74 employees (up 34 percent) and revenues have grown on average from $9.3 million to $21.5 million (up 131 percent). However, 86 percent of this revenue increase is attributable to commercial and other non-defense business. In fact, one of the original case study company's defense revenues are down to a mere trickle. Overall, these statistics represent a tribute to the commercial success, persistence, and capabilities of these companies. They also remind us of the barriers to these companies' entry into the defense enterprise.

This series has often commented on the cultural change required to move acquisition professionals from platform-focused to capabilities-based thinking. Our analysis of tools at the disposal of program managers and other acquisition professionals has convinced us that, by and large, the necessary flexibility exists in Department acquisition regulations and business practices. However, it is up to senior Department acquisition leaders to craft programs that enable networked, cross-Service, and cross-application capabilities.

As this report goes to print, the Department's acquisition and budgeting decision-making processes are transitioning to this functional capabilities lens. As part of the Defense Acquisition Executive Summary (DAES) process, the Department has been reviewing program cost, schedule, and capability issues in the functional capability groupings for over a year.[4] Capability area reviews for Integrated Air and Missile Defense, Joint Battle Management Command and Control, and Land Attack Weapons based on roadmaps, architectures, and mission areas have been reviewed by the DAB members over the last year. The office of the USD(AT&L) has developed concepts to scale such oversight reviews to the larger functional capability lens. These oversight reviews likely will commence as architectures and roadmaps are available to provide this broader context.

Finally, this report recommends that the Industrial Base Investment Fund, intended to fund producible innovation not otherwise available to ongoing programs, be included in the Department's FY07 budget request. Once funded, the Industrial Base Investment Fund will provide the Department a structure, such as In-Q-Tel or industry Chairman Innovation Funds, to move innovation into and throughout the defense enterprise faster and more directly—providing traditional and emerging defense suppliers the better on-ramps we envisioned and began crafting in 2002.

[4] Transition initiated on October 15, 2003, and then realigned on August 16, 2004, via memoranda from USD(AT&L).

RED TEAMS

Functional Capabilities Red Team

Vice Admiral (Ret) John A. Lockard, Senior Vice President Naval Systems, The Boeing Company
Mr. Jon Jones, Vice President, Raytheon Missile Systems
Mr. Robert Haffa, Director, Analysis Center, Northrop Grumman Corporation
Ms. Mona Lush, Acting Deputy Director, OUSD(AT&L)/Acquisition Resources & Analysis
Colonel Brian Baldy, Deputy Chief Force Application Assessment Division, Joint Staff (J8)

Industry Red Team

Ms. Marina E. Pavlatos, Chief Executive Officer, Arkcove Industries
Dr. A. Michael Andrews, Chief Technology Officer, L-3 Communications Holdings, Inc.
Mr. Paul Bazitz, Vice President & General Manager, Lockheed Martin
Mr. Richard Diamond, Vice President of Business Development, BAE Systems

Industrial Base Investment Fund Red Team

Mr. Pete Geren, Special Assistant to the Secretary of Defense
Mr. Frank Lanza, Chief Executive Officer, L-3 Communications
Dr. William Ribick, Chief Executive Officer, Foster Miller
Mr. Paul Pasquier, Director of Supply Chain Management, Boeing Phantom Works
Mr. Mark Peterson, Director, Program Resources & Integration/DDR&E
Ms. Harriet Goldman, DeVenCI, DUSD(S&T)

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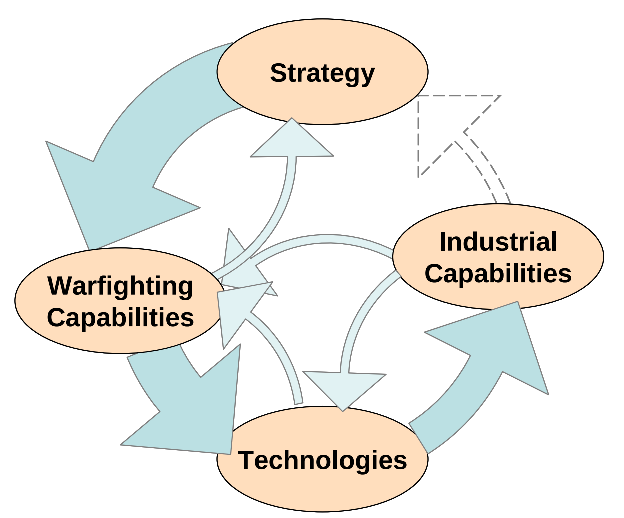
Executive Summary

In February 2003, the Office of the Deputy Under Secretary of Defense for Industrial Policy, ODUSD(IP), produced *Transforming the Defense Industrial Base: A Roadmap*. This report identified the need for systematic evaluation of the ability of the defense industrial base to develop and provide functional, operational effects-based warfighting capabilities. The Defense Industrial Base Capabilities Study (DIBCS) series is a systematic assessment of critical technologies needed in the 21st century defense industrial base to meet warfighter capabilities, as framed by the Joint Staff's functional concepts. In addition, the DIBCS series provides the basis for strengthening the industrial base required for 21st century warfighting needs. This report addresses the third of those functional concepts, Force Application.

The DIBCS methodology associates enabling technologies with warfighter capabilities and assesses the industrial base's ability to develop and produce those technologies. It defines national leadership goals for warfighter capabilities (*Neutral, Equal, Be Ahead, Be Way Ahead*) that establish the degree of innovation desired in the industrial base. A warfighting capability that is ubiquitous—mature and available to all countries—typically has a *Neutral* capability leadership goal. Technologies linked to *Neutral* warfighting capabilities require minimal innovation and can be sourced from the global marketplace. In contrast, a warfighting capability that brings key U.S. advantages has a *Be Way Ahead (BWA)* capability leadership goal. Technologies associated with *BWA* warfighting capabilities must lead by multiple technology generations, must be highly innovative, and often require effective competition among suppliers to be sustained. The graphic opposite shows the relationship between the Joint Staff's capabilities-based strategy and the industrial capabilities the DIBCS methodology assesses.

Capabilities-Based Influence Cycle



The purpose of this process is to explicitly influence the strategy formulation of the Department, recognizing that the formulation of these inputs can be done most completely once all five DIBCS assessments are completed. This tie-in to strategy is also contingent on the synchronization of Department process changes to this new functional capabilities construct.

Source: ODUSD(IP) and Booz Allen Hamilton

The DIBCS series focuses on *critical* technologies—those linked to *Be Ahead* (*BA*) and *BWA* warfighter capabilities—and then proactively assesses industrial base sufficiency for the priority critical technologies.

Finally, the DIBCS series recognizes that managing key industrial capabilities may require policy and process changes. As

such, it serves as a forum for monitoring the implementation of policy and process changes necessary to strengthen the industrial base available to the Department.

Program managers have a direct impact on the industrial base. Therefore, in this study we examined program management tools and associated acquisition strategies to determine whether they were suitable for managing programs in the functional capabilities context. To accomplish this, we developed an extensive taxonomy to analyze program management practices and structures for Force Application (FA) programs. This analysis convinced us that government program managers have the necessary acquisition policy tools to manage in this new construct, especially with the flexibility provided in these policies and as reiterated by the USD(AT&L) in July 2004.[5]

A second initiative examined the extent to which Department acquisition oversight processes are consistent with the new functional capabilities construct. Much work has been done, but much still remains to be done. The Department is conducting DAES reviews using this broader lens, and the DAB has reviewed a number of non-program specific capability areas. The scale of these reviews falls short of the functional capabilities construct established by the Joint Staff's Joint Functional Concepts.[6] The Program Managers' Functional Capability Conference/Capability Area Review process is a blueprint for larger scale reviews, and could commence as soon as mid-2005.

The third initiative addresses the imperfections of the on-ramps available to companies that have leading-edge, producible technologies relevant to programs of record. Such technologies often remain on the sidelines of the defense enterprise for many reasons. They:

- Do not meet programs managers' funding priorities;
- Are not in the program's scope as originally envisioned;
- Are "cutting room floor" technologies from losing bids difficult to assimilate due to intellectual property or acquisition regulation restrictions; or
- Are not completely aligned with current requirements (like those on our "Watch List").

To provide better program on-ramps for such innovations, we have begun developing the Industrial Base Investment Fund (IBIF), which would be managed by the office of the USD (AT&L) in a manner similar to Chairman Innovation Funds in industrial settings or the CIA's In-Q-Tel. Initial funding could be secured in the FY07 budget.

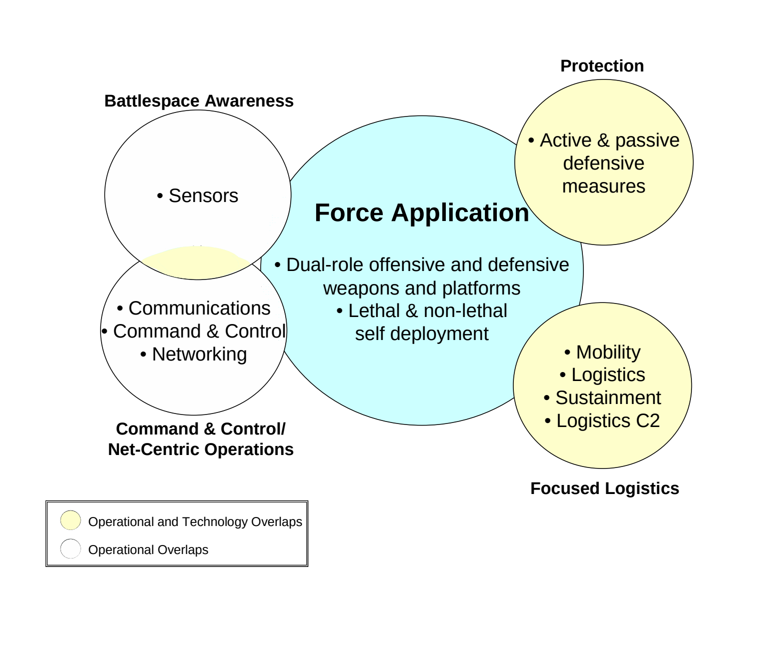
[5] USD(AT&L) memorandum entitled "Responsiveness of the Acquisition System of the High Priority Needs of the Deployed Warfighter," dated July 8, 2004.

[6] *Functional Concept for Battlespace Awareness*, published December 31, 2003; *Protection Joint Functional Concept*, published December 31, 2003; *Focused Logistics Joint Functional Concept*, published December 2003; *Force Application Functional Concept*, published February 2004; and *Joint Command and Control Functional Concept*, published February 2004.

THE ROLE OF FORCE APPLICATION

This study begins with understanding the Force Application (FA) functional concept. At its core, FA is about maneuvering and engaging to apply force in all target domains to accomplish desired effects. FA contains the functional capabilities most associated with the execution end of the "kill chain."

JOINT FUNCTIONAL CONCEPTS: OPERATIONAL AND TECHNOLOGY RELATIONSHIPS



Source: ODUSD(IP) and Booz Allen Hamilton

FA is "where it all comes together" as the graphic opposite shows. Battlespace Awareness (BA) provides the sensor data to identify targets. The data is communicated and continually updated in two-way communications provided between Command and Control (C2) and FA capabilities.

In the broadest sense, Focused Logistics (FL) capabilities provide support to the FA assets so that they can get to the conflict—for example, a C-17 transports the M1A2 to the theater. But for the purposes of *DIBCS FA*, those capabilities that allow self-deployment and battlefield maneuver are included in FA. FA also covers assets with capabilities for use in both offensive and defensive roles. Those assets associated with strictly defensive capabilities (i.e., PAC-3 or THAAD) will be covered in the Protection report.

Finally, the chart shows that while there are operational overlaps between FA and all other functional concepts, there are also technology overlaps with the Protection and FL concepts. Propulsion and structures technologies are found in FA, Protection, and FL. Weapons technologies are found in FA and Protection—in large measure because missile defense is a Protection asset. Where possible, we treated technologies comprehensively, but not exhaustively, in one functional concept. For example, we included aircraft propulsion technologies enabling FA and FL assets such as the B-2 and C-17, respectively, within the FA functional concept because FA requires the most demanding propulsion technologies. By contrast, we included protective coating technologies for FA assets in the Protection functional concept because the purpose of these technologies is to *protect* the assets on which they are applied.

Where it is not practical to isolate a technology to FA, Protection, or FL, we will endeavor to discuss it in the functional capability where it is most mission-essential but provide cross-references as necessary. In some cases, technologies are treated in multiple reports of the DIBCS series because applications of specific technologies are significantly different. For example, weapons propulsion technologies are treated in both FA and Protection; hypersonic weapon propulsion system technologies are treated in FA; rocket motors for interceptors are treated in Protection.

FORCE APPLICATION RECOMMENDATIONS

Our review identified 1,036 specific warfighting capabilities supporting FA. Of these, 787 capabilities were ones in which the United States should maintain a lead of at least one technology generation. Translation of these latter capabilities yielded 212 associated critical enabling technologies. We assessed 32 of the most important of these technologies and 29 associated component technologies—for a total of 61 technologies assessed for industrial base sufficiency. While in general, U.S. defense suppliers hold a technological advantage over foreign competitors for FA technology, a larger number of leadership or sufficiency of supply issues were found in FA than in the previous studies: six in FA versus three each in BA and C2. We surmise that this is because most nations seeking military capabilities focus on FA capabilities, thereby creating a more competitive field globally.

RECOMMENDATION 1

The Department should implement remedies to address two categories of issues.

- We identified technologies that are not likely to be part of the U.S. warfighting arsenal. They are important because they represent unusual technical solutions and could pose challenges to U.S. warfighters if proliferated elsewhere. We have created a "Watch List" to document these technologies for further consideration and policy remedies:

  - Million-Rounds-Per-Minute Gun ("Metal Storm");
  - Electro-Hydraulic Cavitation Device.

- We also identified six industrial capabilities needing additional attention to obtain or sustain the desired degree of U.S. capability leadership or supplier sufficiency:

  - Pulsed Plasma Thruster;
  - Hypersonic Weapon Propulsion System;
  - Small Caliber Projectile Control Surfaces;
  - GPS-Guided Small Diameter Bomb (SBD);
  - Chemical Oxygen-Iodine Laser (COIL);
  - Self-Propagating High-Temperature Synthesis Device.

RECOMMENDATION 2

The Department should reinforce acquisition policies that empower program managers to flexibly and effectively manage programs within functional capability constructs. Based on our work to date, and the objective to continue to infuse programs with innovation and technological advances, we support acquisition policies that allow program managers this essential flexibility.

RECOMMENDATION 3

The Department should continue to expand the capabilities-based lens of program oversight. We remain committed to the postulate that a common vernacular in all Department processes will forge better links between the industrial base and the warfighter it serves. As part of the USD(AT&L)'s strategic objectives to bring acquisition oversight processes into this functional capabilities context, efforts are underway to scale up capability area reviews for Air and Missile Defense (AMD), Land Attack Weapon Review (LAWR), and Joint Battle Management Command and Control (JBMC2) to the more ambitious functional capabilities view. It is hoped that this functional capability-based acquisition oversight process will be validated through five successive prototyping exercises conducted in 2005 so as to be available for Department leadership for the FY07 budget deliberations.

RECOMMENDATION 4

The Department should establish the Industrial Base Investment Fund (IBIF) to provide better on-ramps for production-ready technologies nominated by emerging innovative suppliers and by company or Department program managers. The Department is in the early stages of conceptualizing the IBIF that would be funded to provide better on-ramps for innovation. It leverages and synergizes lessons learned from similar funds and transition vehicles available in the Department and in commercial businesses. We will continue refining this concept, planning to fund this vehicle by FY07.

RECOMMENDATION 5

Within the Department, ODUSD(IP) should continue to be the clearinghouse for strengthening the industrial base. ODUSD(IP) will further assess Force Application industrial base sufficiency using the capabilities framework, databases, and policy tools of the DIBCS process. This framework will also be used for industrial base capabilities assessments for Protection and Focused Logistics, as it has been for Battlespace Awareness and Command and Control. ODUSD(IP) maintains insight into Service, Defense Agency, and other Department industrial base activities in its day-to-day responsibilities, as well as those involving other parts of the Executive Branch. It will continue to oversee the industrial base impacts of these organizations' individual actions and policies.

THE LARGER DIBCS EFFORT

DIBCS Report	Publication Date
Battlespace Awareness	January 2004
Command & Control	June 2004
Force Application	October 2004
Protection	December 2004
Focused Logistics	May 2005

FA is the third of our industrial base assessments. By mid-2005, we will examine two additional functional concepts. All DIBCS assessments will be informed by Joint Staff and other sources that update and further define required warfighting capabilities.

The DIBCS process was initiated to provide a rigorous, systematic analytical framework to examine industrial base sufficiency issues for the joint functional concepts most dependent on materiel solutions. As this study series completes by May 2005, this framework and its findings will continue to inform other Department, industry, and allied processes related to defense industrial base issues. Comprehensive communication and implementation of the DIBCS series' findings will be addressed once all five studies have been completed. However, already the individual studies have served to strengthen the industrial base and processes associated with the U.S. and global industrial base.

A major strength of this study series is the real time insight it is providing to Department processes and policy developments. The DIBCS series, and issues identified in the series, already are informing DoD evaluations and actions.

For example, active hyperspectral imagery was identified as an issue in the BA study. Potential technologies of interest to the Department have been identified at Lawrence Livermore Laboratory and in the Australian industrial base and are being pursued by the Department. Swarming control tools were identified as an industrial base issue in the C2 study, and at least one additional potential source has been identified working these issues.

In addition to being a tool for technology finding, the DIBCS study series has informed our deliberations related to merger and acquisition transactions. There are numerous examples where our assessment of Hart-Scott-Rodino (HSR) and Committee on Foreign Investment in the United States (CFIUS) mergers and acquisitions considered the critical technology industrial base issues identified in these reports on a real time basis.

For example, the swarming/autonomous control tools identified in the C2 study were considered in three HSR/CFIUS transactions over the last two months. Of the three cases examined, relevant capabilities were not found in one; one transaction was withdrawn as a consequence of the issue being raised; and in the third, reporting arrangements have been crafted to assure appropriate alignment of the U.S. and foreign corporate strategic interests. Another technology capability, active magnetic signature reduction, has already been considered in a CFIUS transaction just completed—on the basis of data generated for *DIBCS: Protection* to be published in December 2004.

In another DoD initiative, the ODUSD (International Security Policy) is establishing a website that, among other things, will link information associated with DoD export licensing reviews to the DIBCS series and other technology information. Export control is highlighted in our remedies to industrial base issues, and some of these technologies would qualify for export control and, once assessed more fully, be candidates for the Militarily-Critical Technology List (MCTL). It is hoped that the DIBCS series will inform the larger ongoing discussions associated with updating the MCTL, the basis for export licensing reviews involving military technology.

One of the recommendations of *DIBCS BA* was to ensure acquisition strategies systematically cultivate innovation throughout the lifecycle of programs. Acting on this recommendation, the Department has developed—and published in the recently-released DoD Acquisition Guidebook—program strategy guidelines that encourage program managers to develop technology plans and acquisition strategies that fund innovation and seek synergies in related programs within common functional concept capabilities areas.

In both *DIBCS BA* and *DIBCS C2,* we identified concerns that contractors might favor in-house capabilities or long-term teammate products over more innovative solutions available elsewhere. To address such concerns, the Acting USD(AT&L) recently issued guidance for Service Acquisition Executives, Program Executive Officers, and program managers to ensure that they do not cede to vertically integrated prime contractors the ability to select internal capabilities at the expense of better capabilities available from external sources. Instead, he directed DoD program officials to retain the right to disapprove such sub-optimized subcontracting decisions.

While our work on the DIBCS series is still just beyond mid-point, the vernacular and methodology it deploys are already being echoed in U.S. and global corporations interested in supplying technology for future generations of warfighters. In fact, numerous foreign governments have expressed an interest in adapting our methodology to assessments of their respective industrial bases.[7]

Our staff has also spent considerable time briefing the European Defense Agency and its member nations on this assessment tool. Our common efforts in this regard are based on the postulate underlying our own efforts: if disparate industrial base capabilities are to improve warfighting capabilities, sufficiency analyses and the associated industrial base planning must begin with a broad understanding of *warfighting capabilities* required. To base assessments on what is currently available in a given industrial base or on individual constituent interests dooms the warfighter and the industrial base to the status quo. Only by looking to the future can we transform the industrial base to support the operational ethos: warfighting capabilities, and the warfighter, must drive defense demand and the products the Department acquires.

[7] ODUSD(IP) has had extensive discussions on the DIBCS methodology with representatives from Australia, Austria, Germany, Italy, Japan, Korea, the Netherlands, Singapore, Sweden, Turkey, and the United Kingdom.

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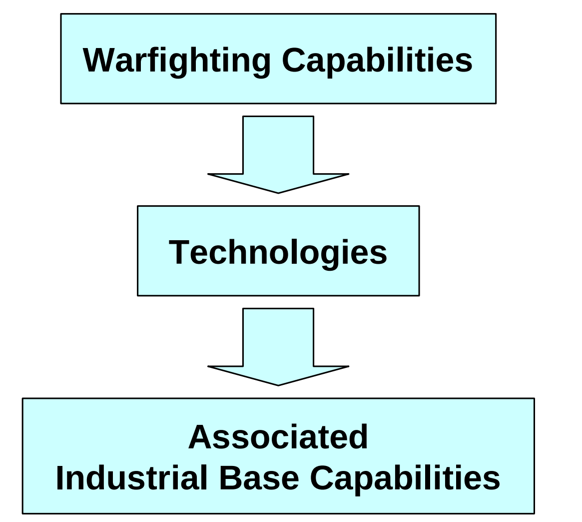
PART I

MEETING THE CHALLENGE

Our February 2003 report, *Transforming the Defense Industrial Base: A Roadmap*, reflected a revolutionary warfighting doctrine then germinating within the Department. Since then, the Department has organized around functional concepts defined by the Joint Staff that focus the Department's resources on the most essential operating effects that the U.S. warfighter must deliver in order to win. To help the industrial base respond to this new challenge, the DIBCS series communicates these needs and this capabilities-based approach, as well as recommends—and implements, as appropriate—associated policies.

ROADMAP TO THE FUTURE

DEFENSE INDUSTRIAL BASE CAPABILITIES STUDY TRANSLATION PROCESS



Source: Booz Allen Hamilton and ODUSD(IP)

The DIBCS series represents a structured, top-down analysis and policy framework with which Department decision-makers can harness the full power of competition to address key warfighting capabilities and unleash innovation in academia, industry, and the Government. The DIBCS series identifies warfighting capabilities, the critical enabling technologies that support those warfighting capabilities, and the industrial base capabilities associated with those technologies. The series also highlights and addresses industrial base concerns across life cycles of programs.

The Department's move towards capabilities-based planning will fundamentally change the defense enterprise. It is changing the manner in which the Department identifies and prioritizes military capability requirements, focusing its attention on enabling capabilities—often acquired in families-of-systems or systems-of-systems. Inherent in this shift are changes in doctrine and the way the Department manages the development and acquisition of these capabilities. How the Department looks at what it has and what it needs will also affect who participates in the defense industrial base—and challenge the Department to make better use of a broader base of suppliers.

The Joint Staff's initial five functional concepts where materiel solutions are most important are: Battlespace Awareness (BA), Command and Control (C2), Force Application (FA), Protection, and Focused Logistics (FL). Our translation of these concepts extends a common and comprehensive vernacular from the operators to the acquirers and industry. The landscape of the future, as depicted on the front cover of this report and illuminated on the front flyleaf, is still evolving. Accordingly, we continue

to adjust our industrial capability assessments to reflect the latest evolution of the Department's concepts. This integrated vision will improve the efficiency of resource and operational planning, and associated decision-making and program execution—within the Department and industry. Applying this integrated vision with diligence will greatly increase the Department's confidence that critical industrial base capabilities are available when needed to maintain U.S. warfighting superiority. It will be up to the Department's leadership to structure programs that effectively draw on industrial base capabilities to meet warfighters' 21st century requirements.

THE DEFENSE INDUSTRIAL BASE CAPABILITIES STUDY METHODOLOGY

The Department's industrial policy challenge is to evaluate the industrial base in this capabilities-based framework and to recommend actions and policies to ensure the industrial base can develop the technologies and produce the systems and weapons required.

JOINT STAFF JOINT FUNCTIONAL CONCEPTS[8]	
Battlespace Awareness Global Hawk, DCGS, NPOESS, SBIRS-High, E-2 Advanced Hawkeye	Capabilities of commanders and force elements to understand their environment and the adversaries they face. Uses a variety of surveillance capabilities to gather information; a harmonized secure netcentric environment to manage this information; and a collection of capabilities to analyze, understand, and predict.
Command and Control[9] FBCB2, AOC-WS, MPS	Capabilities that exercise authority and direction over forces to accomplish a mission. Involves planning, directing, coordinating, and controlling forces and operations. Provides the means to recognize what is needed and ensure that appropriate actions are taken.
Force Application JDAM, MM III, F/A-22, MH-60R, JSF, CVN21, FCS, GMLRS	Capabilities to engage adversaries with lethal and non-lethal methods across the entire spectrum of conflict. Includes all battlefield movement and dual-role offensive and defensive combat capabilities in land, sea, air, space, and information domains.
Protection ATIRCM/CMWS, PAC-3, Chem Demil	Capabilities that defend forces and U.S. territory from harm. Includes missile defense and infrastructure protection and other capabilities to thwart force application by an adversary.
Focused Logistics C-130, CH-47, GCSS, MPF, T-AKE, C-17, FMTV, MH-60S, C-5 RERP	Capabilities to deploy, redeploy, and sustain forces anywhere in or above the world for sustained, in-theater operations. Includes traditional mobility functions of airlift, sealift, and spacelift as well as short-haul (intra-theater and battlefield) transportation. Also includes logistics C2, training, equipping, feeding, supplying, maintaining and medical capabilities.
Source: Joint Functional Concepts and ODUSD(IP)	

Beginning with Battlespace Awareness, then Command and Control, and progressing now to Force Application, the DIBCS series assesses the sufficiency of the industrial base for priority critical technologies in each functional capability area. These studies—as well as those following on Protection and Focused Logistics—use the same methodology to assess critical technology and industrial base capabilities in each

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[8] A sampling of major programs is aligned with each functional concept to provide an illustration of that area's scope. Not all of the warfighter capabilities supplied by a program fall into a single sector, however. All acronyms are defined in the Acronym List beginning on page 65.

[9] A new functional concept, Network Centric Operations (NCO), has recently been developed. The *DIBCS C2* report published in June 2004 included capabilities relevant to that functional concept. As the NCO functional concept is finalized, the DIBCS series will be reviewed for completeness in assessing the NCO industrial base capabilities.

functional capability area.[10] The methodology is consistent with the operational ethos embodied in the U.S. defense industrial base: warfighting capabilities, and the warfighter as the primary constituent, must drive defense demand and the products the Department acquires.

This methodology categorizes warfighting capabilities according to the desired leadership they give the United States over potential adversaries. As described in the table below, extra attention is focused on those warfighting capabilities where the United States should lead any potential adversary. Less attention is focused where leadership is not possible or not particularly advantageous. Ideally, the Department would wish to have a significant lead in every warfighting capability. Practically, however, the Department cannot do so.

LEADERSHIP GOALS	
Neutral	Position relative to potential adversaries is immaterial.
Equal	Desire capability at least as good as potential adversaries; systems are likely in a common technological generation.
Be Ahead (BA)	Desire a significant capability difference over potential adversaries; systems should likely lead by a technology generation or order of magnitude better performance in key attributes.
Be Way Ahead (BWA)	Desire a very significant capability difference over potential adversaries; systems should likely lead by multiple technology generations or orders of magnitude in performance.

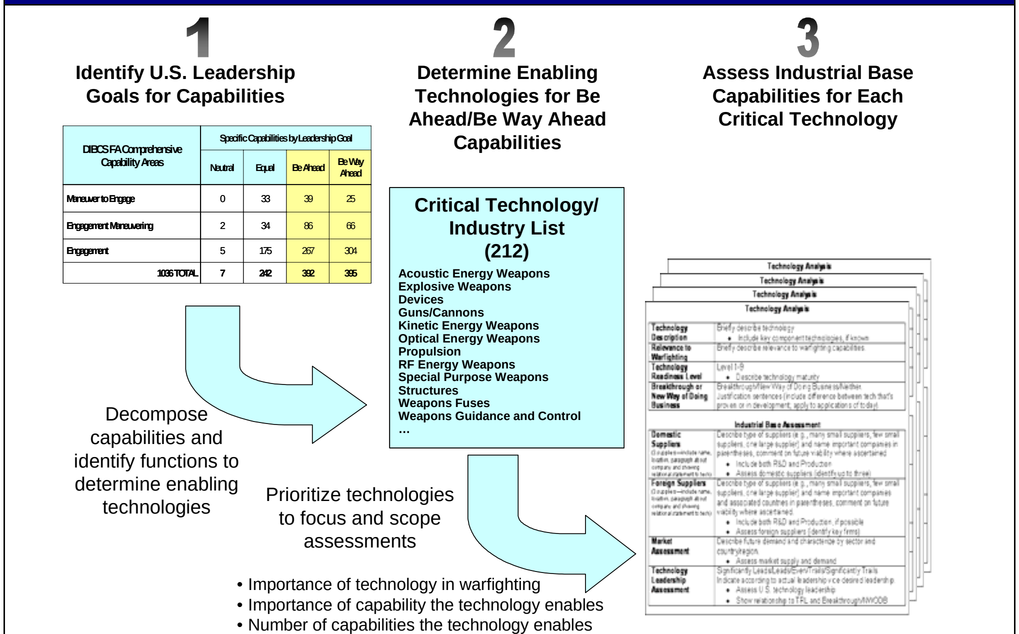
Source: Booz Allen Hamilton and ODUSD(IP)

In addition, operational concepts will change over time, and the Department should focus most on those capabilities where leadership will provide the warfighter the greatest advantage. Our methodology gives added weight to the most important of these capabilities. Our objective is to concentrate Department of Defense (DoD) attention and scarce resources on the areas that make the biggest difference in 21st century joint military operations: those warfighting capabilities for which the Department must have *Be Ahead* and *Be Way Ahead (BA/BWA)*[11] leadership goals.

Therefore, we focus on the warfighting capabilities where the Department needs to achieve and maintain the greatest lead; then we identify the priority critical technologies that enable these capabilities and provide assessments of the associated industrial base. When an industrial base deficiency—whether immediate or projected—is identified, we examine it in more depth and recommend remedies.[12] This analytical process, further elaborated on the next page, has three basic steps: identify warfighter capability leadership goals; determine and prioritize associated technologies; and assess the industrial base associated with those technologies.

[10] Adapted from the *Space R&D Industrial Base Study*, Booz Allen Hamilton, August 2002.
[11] For clarity, functional capabilities, leadership goals, and policy tools are italicized; Joint Staff operational capabilities are in quotation marks.
[12] For a more detailed discussion of these potential policy remedies, see Appendix D which contains an excerpt from *DIBCS BA* outlining these portals and levers.

DEFENSE INDUSTRIAL BASE CAPABILITIES STUDY METHODOLOGY



Source: Booz Allen Hamilton and ODUSD(IP)

1. Identify U.S. Leadership Goals for Warfighting Capabilities. This industrial base study series uses research and analysis teams of subject matter experts to identify detailed warfighting capabilities derived from each of the Joint Staff's functional concepts and the *Universal Joint Task List*.[13] A DIBCS Senior Advisory Group (SAG) of retired senior military and civilian DoD leaders and selected industry experts guides the subject matter experts. The DIBCS SAG then oversees the selection of the leadership goal for each identified capability based on the advantage it provides the United States in executing joint operations in the 21st century.[14]

2. Determine and Prioritize Critical Technologies for *BA/BWA* Capabilities. Once these goals have been vetted by cognizant organizations within the Department, the team identifies the

***DIBCS FA* SENIOR ADVISORY GROUP**
WITH FORMER RELEVANT POSITIONS AND EXPERTISE NOTED*

Gen. (Ret) Thomas S. Moorman, Jr. [(a)]
Vice Chief of Staff, USAF

VADM (Ret) Lyle G. Bien [(b)]
Deputy Commander in Chief, USSPACECOM
Commander, Carrier Battle Group 7, embarked in USS Nimitz

Mr. Cosmo DiMaggio III [(c)]
Industry Expert, Technology Research

LTG (Ret) Robert Noonan [(a)]
Deputy Chief of Staff, Intelligence, Army

RADM (Ret) Robert M. Nutwell [(a)]
Deputy Asst Secretary of Defense for C3I
Commander, Combined Task Force Fifty, embarked in USS Abraham Lincoln

Ms. Renata F. Price [(a)]
Science Advisor, Deputy Chief of Staff, Research, Development and Acquisition, Army Materiel Command

Dr. Edward L. Warner [(a)]
Asst Secretary of Defense for Strategy and Requirements
Asst Secretary of Defense for Strategy and Threat Reduction

* All Department and military affiliations are former positions; SAG composition varies by functional area.
(a) Currently with Booz Allen Hamilton
(b) Independent Consultant
(c) Currently with the Tauri Group

[13] Chairman of the Joint Chiefs of Staff Manual 3500.04C, *Universal Joint Task List*, July 1, 2002.
[14] See Appendix A for *DIBCS FA* capability framework.

critical enabling technologies for those warfighting capabilities with leadership goals rated *BA/BWA*. The DIBCS SAG oversees a team of subject matter experts to identify and prioritize these technologies, using a variety of sources such as the *Joint Warfighting Science and Technology Plan.*[15] They then establish the priority of a technology using three factors. The first factor is the importance of the technology in enabling warfighting impact in a breakthrough, transformational, or critically essential manner. The second factor is the importance of the specific capability the technology enables: for example, it is more important to enable a *BWA* than a *BA* capability. The third factor is the span of impact of the technology in enabling multiple capabilities.

3. Assess Industrial Base Capabilities for Each Priority Critical Technology. Finally, the study examines the industrial capabilities necessary to supply these critical technologies, in priority order. This generally involves identifying the major domestic and foreign suppliers and examining them for sufficiency and suitability. When applying this methodology, we focus on a limited number of high priority, critical technologies which we examine in detail. The purpose of the initial assessment is to form a broad understanding of sufficiency and risk in the most important elements of each functional capability area's industrial base. If this assessment identifies a concern, the study notes the deficiency and potential remedies for further investigation. We document the remaining technologies so they can be addressed to the same level of detail later, as resources permit.

Part of this assessment is to compare domestic industrial capabilities with foreign capabilities. To provide the best capability possible to the warfighter, the Department will look for best value throughout the global industrial base. If the Department uses a foreign supplier to support a *BA/BWA* capability, however, it must manage certain risks this could entail. Broadly, these risks are: assurance of supply, technology security, and congruency of strategic interests. Assurance of supply relates to having access to the defense products the Department needs when it needs them. Technology security relates to controlling potential adversary access to the U.S. and global industrial base that supplies our warfighters. Congruency of strategic interest describes the desired alignment of corporate interests and strategic planning with U.S. interests and objectives. In assessing whether particular foreign sources represent acceptable risk, the Department must look at numerous factors including the criticality of the technology involved, the status of foreign relations with the other countries involved, and the likely leverage the United States can have on the focus of foreign sources.

JUST THE BEGINNING

We believe that this capabilities-based framework will help decision-makers understand and address industrial base deficiencies. The first round of studies will be completed in 2005. However, this is just the beginning. The baseline will continue to evolve as the Joint Staff implements its joint functional concepts and as the Department

[15] United States, Director, Defense Research and Engineering, Department of Defense, *Joint Warfighting Science and Technology Plan*, February 2002.

simultaneously continues to assess the industrial base supplying those corresponding capabilities. The study series should help companies large and small—and indeed the whole of our defense industrial enterprise—have more direct insight into the critical industrial base capabilities required for 21st century warfare. This insight should better inform individual firm investment decisions and strategic planning as well.

The DIBCS series develops a logical, capabilities-based approach to identifying and understanding industrial base sufficiency. It fits naturally into the evolving acquisition and requirements processes. It also provides a firm basis for identifying industrial base deficiencies and potential remedies.

PART II

INDUSTRIAL BASE CAPABILITIES IN FORCE APPLICATION

This study applies the DIBCS methodology to the FA functional capability area, establishing leadership goals for FA warfighting capabilities. Using this warfighting capabilities-based analysis, the study identifies technologies which enable the functional concept and provides an assessment of the industrial base for a prioritized subset of those technologies. It also develops a "Watch List" of unique technologies that represent unusual technical solutions—and could pose challenges to U.S. warfighters if proliferated elsewhere.

REFINING THE FORCE APPLICATION (FA) FUNCTIONAL CAPABILITY AREA

In its simplest form, FA is the maneuver and engagement of U.S. combat forces to generate lethal and non-lethal effects on the adversary.[16] The graphic below depicts the Joint FA Functional Concept (JFAFC) capabilities as translated for the DIBCS process. The JFAFC defines "Maneuver" as the movement of forces into and through the battlespace to engage from a position of advantage. In order to fully assess all potential technologies that enable maneuver, it was necessary to divide this functional capability into two distinct capabilities—"Maneuver to Engage" and "Engagement Maneuvering." This separation allows for the identification of technologies key to the capability to maneuver *to* the battlespace, as well as those technologies associated with maneuvering *in* the battlespace.

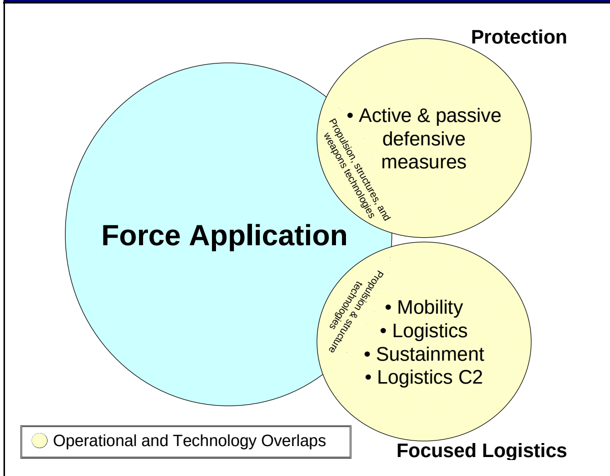
JFAFC CAPABILITIES	*DIBCS FA* CAPABILITIES	CAPABILITY DEFINITION	CAPABILITY EXAMPLE
Maneuver	Maneuver to Engage	Capabilities to maneuver *to* the battlespace	• Long range self-deployment
	Engagement Maneuvering	Capabilities to maneuver *in* the battlespace	• Super-cruise maneuvering
Engage	Engagement	Capabilities to engage a range of adversaries in any domain from any domain to achieve desired effects	• Shoot fixed ground-based target from sea (air or ground)
Source: ODUSD(IP) and Booz Allen Hamilton			

As for the capability to "Engage," the JFAFC defines it as the use of kinetic and non-kinetic means to generate the desired lethal and/or non-lethal effects. Again, to ensure full assessment of all associated technologies, "Engage" is defined as the capability to engage a range of adversaries *in* any domain *from* any domain to achieve desired effects. This subtlety in interpretation forced this study to account for all combinations of potential engagement scenarios.

[16] See discussion of operational relationships among the five functional concepts in the Executive Summary, pages 3-4.

As much as distinctions between platforms that maneuver *to* the battlespace and platforms that maneuver *in* the battlespace often blur, associated technologies also may be common to multiple platforms and their functional concepts. For example, in the case of C-17 strategic lift capability in Focused Logistics (FL) and B-2 stealth capabilities in Protection, FA shares enabling technologies such as propulsion, structures, and materials with the other functional concepts. This is depicted in the graphic opposite as the technology overlap between these functional concepts.

JOINT FUNCTIONAL CONCEPTS: DIBCS TECHNOLOGY OVERLAPS



Sources: Booz Allen Hamilton and ODUSD(IP)

Where possible, we treated technologies comprehensively in one functional concept. For example, we included aircraft propulsion technologies enabling FA and FL assets such as the B-2 and C-17, respectively, within the FA functional concept because FA requires the most demanding propulsion technologies. By contrast, we included protective coating technologies for FA assets in the Protection functional concept because the purpose of these technologies is to protect the assets on which they are applied.

Where it is not practical to isolate a technology to FA, Protection, or FL, we will endeavor to discuss it in the functional capability where it is most mission-essential but provide cross-references as necessary. In some cases, technologies are treated in multiple reports of the DIBCS series because applications of specific technologies are significantly different. For example, we treated weapons propulsion technologies in both FA and Protection—hypersonic weapon propulsion system technologies in FA and rocket motors for interceptors in Protection.

FA provides the core maneuver and engagement capabilities used to accomplish desired effects upon an adversary. To ensure sufficiency, the Department must be able to translate warfighter capabilities to enabling technologies and the associated industrial base—the DIBCS methodology does this.

TRANSLATING THE FA CAPABILITY AREAS TO INDUSTRIAL CAPABILITIES

The DIBCS series employs a systematic assessment methodology for translating warfighting capabilities to technology and industrial base vernacular to assess industrial base sufficiency.

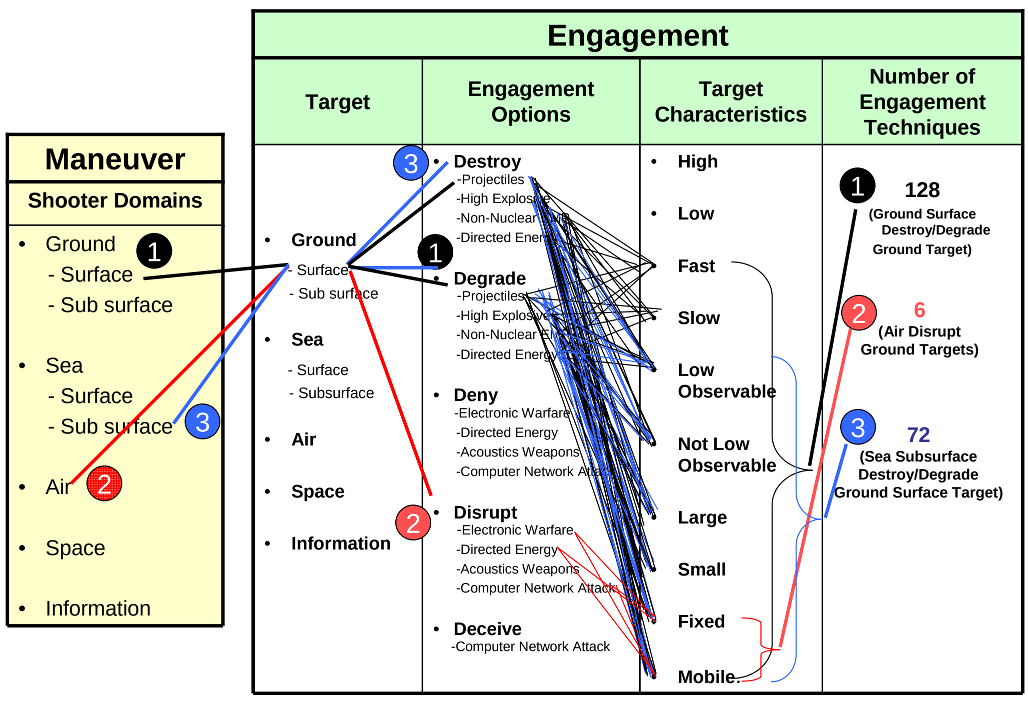
Why So Many FA Warfighting Capabilities?

The American way of war relies on a robust set of FA capabilities to allow U.S. forces to maneuver and engage an adversary in any operational domain, using myriad engagement techniques. The graphic below depicts the seven shooter or “Maneuver” domains. Moving to the right, it then displays the seven target domains “Engagement” options available to U.S. forces follow, along with the number of engagement options which the assessment methodology takes into account. As one moves from the “Maneuver” domain through the “Engagement” domain, the methodology accounts for all potential engagement techniques. These variables are portrayed below as a mathematical progression:

Shooter x Target x Engage Options x Target Characteristics =	**Number of Engagement Techniques**

This geometric progression explains the significant increase in the number of FA *BA/BWA* warfighting capabilities compared with those identified in the BA and C2 studies (787 versus 357 and 189, respectively). Using just the three FA engagement examples highlighted in the illustration below yields 206 engagement techniques—each associated with discrete *BA/BWA* warfighting capabilities.

Three FA Engagement Examples & Associated Techniques



Ensuring nimble, flexible force applications requires significant numbers of engagement techniques and warfighting capabilities

Sources: Booz Allen Hamilton and ODUSD(IP)

The discussion below elaborates these FA engagement examples:[17] a ground/surface capability destroying/degrading a ground target; an air capability disrupting a ground target; and a sea subsurface capability destroying/degrading a ground surface target. These examples illustrate why such significant numbers of FA warfighting capabilities are required to ensure nimble, flexible options for U.S. 21st century warfighting.

1. Ground and surface capabilities can either destroy or degrade a ground target by using four different engagement options: projectiles, high explosives, non-nuclear electro magnetic pulse (EMP), or directed energy. These engagement options allow operational commanders alternatives for engaging an adversary to maximum advantage. To do so effectively, U.S. capabilities must account for a multitude of target characteristics—for this example, eight: fast, slow, low observable, not low observable, large, small, fixed, or mobile. This particular shooter calculation matched against target characteristics results in 128 potential FA engagement techniques (equation below) which U.S. forces have, or should have, at their disposal.

$$1 \times 1 \times 2(4 + 4) \times 8 = \boxed{128}$$

2. A less complex example would be a U.S. airborne jammer disrupting ground-based fixed or mobile targets. The United States possesses three engagement options: electronic warfare, directed energy, or computer network attack (CNA), to accomplish such tasks. The process of going from the shooter domain, "air," to the target domain, "ground-surface," times the three engagement options available to U.S. warfighters for the two target characteristics, fixed or mobile, yield six distinct FA engagement techniques.

$$1 \times 1 \times 3 \times 2 = \boxed{6}$$

3. Finally, a sea subsurface maneuvering platform can destroy or degrade a ground-surface target by using three different engagement options: projectiles, high explosive, or non-nuclear EMP. This capability must be effective against six key target characteristics: fixed, mobile, large, small, low observable, or not low observable. This scenario yields a potential 72 engagement techniques within FA.

$$1 \times 1 \times 2(3 + 3) \times 6 = \boxed{72}$$

Using this methodology for each pair of shooter-to-target combinations we identified 1,036 specific warfighting capabilities associated with the JFAFC capability areas. Any adversary choosing to challenge U.S. forces faces myriad U.S. engagement techniques. Such a robust set of engagement techniques allows U.S. forces to conduct their own style of asymmetric warfare.

[17] Numbered examples correspond to analysis of engagement techniques in chart on the prior page.

LEADERSHIP GOALS FOR FA WARFIGHTING CAPABILITIES

Using the Joint Staff's JFC as the primary construct, the study team derived capability leadership goals the United States should strive to maintain for each FA warfighting capability, as shown in the summary chart below.

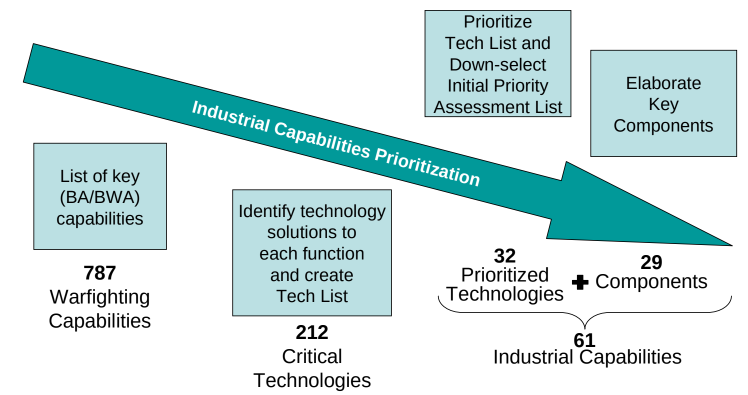
FORCE APPLICATION WARFIGHTING CAPABILITIES SUMMARY CHART				
DIBCS FA Comprehensive Capability Areas	**Specific Capabilities by Leadership Goal**			
	Neutral	**Equal**	**Be Ahead**	**Be Way Ahead**
Maneuver to Engage	0	33	39	25
Engagement Maneuvering	2	34	86	66
Engagement	5	175	267	304
1,036 TOTAL	**7**	**242**	**392**	**395**
Sources: Booz Allen Hamilton and ODUSD(IP)				

For example, in the "Maneuver to Engage" capability area, the study team determined that it was acceptable for the United States to have *equal* capability relative to an adversary's ability to get *to* an engagement using capabilities such as air, ground, and sea transportation. This is because the military applications of these technologies do not provide significant combat advantage. In "Engagement Maneuvering," however, maneuvering speed is of great operational advantage. Hence, supercruise for the F/A-22 or high speed dash for the M1A2 Abrams are *BWA* capabilities to give U.S. forces first shot advantage. And finally, "Engagement" capabilities like precision air and armored track vehicle strike are *BA* capabilities due to the importance of accuracy and lethality.

THE TECHNOLOGY PRIORITIZATION PROCESS

We next identified the technologies associated with each capability to create the technology list. To do this, the DIBCS SAG oversaw a team of subject matter experts to identify and prioritize technologies associated with *BA/BWA* warfighting capabilities; and then assessed industrial sufficiency for a prioritized set of critical technologies. The illustration on the next page summarizes this process.

FORCE APPLICATION TECHNOLOGY PRIORITIZATION PROCESS



Warfighting Capability: A specific ability derived from the Joint Staff Functional Capability Concept (JFC)
Critical Technology: A technical method enabling one or more *BA/BWA* warfighting capabilities

Component: A subset technology used in the assembly of an enabling technology
Industrial Capability: The ability of a manufacturer to supply or produce a technology

Sources: Booz Allen Hamilton and ODUSD(IP)

This study identified a total of 212 critical technologies enabling the 787 *BA/BWA* warfighting capabilities.[18] They are in 13 broad industrial areas as shown below—with half of the technologies associated with *BA/BWA* capabilities in structures, propulsions, devices, and computer network attack (CNA), and the other half in weapons related technologies.

BROAD INDUSTRIAL AREAS FOR FORCE APPLICATION

	Industrial Areas	Technologies for BA/BWA capabilities	Critical Technologies	
			Technologies	Components
Non-weapons	Computer Network Attack	21	2	0
	Devices	23	1	0
	Propulsion	30	5	4
	Structures	37	4	6
Weapons	Acoustic Energy Weapons	6	1	0
	Explosive Weapons	18	3	3
	Guns/Cannons	4	2	1
	Kinetic Weapons	5	2	0
	Optical Energy Weapons	13	3	7
	RF Energy Weapons	17	2	4
	Special Purpose Weapons	19	2	1
	Weapons Fuses	5	2	1
	Weapons Guidance & Control	14	3	2

Sources: Booz Allen Hamilton

[18] These warfighting capabilities and critical technologies are discussed in Appendices A and B.

Of the 212 critical technologies identified, we evaluated industrial sufficiency for 32 priority critical technologies and their 29 associated components, as shown in the table below.

32 PRIORITY CRITICAL TECHNOLOGIES AND 29 ASSOCIATED COMPONENTS ASSESSED IN *DIBCS FA*[19]	
1. Acoustic Energy Weapons—Electro -Hydraulic Cavitation Device 2. CNA—Computer Logic Bomb 3. CNA—Mobile Codes 4. Devices—Common Automated UAV/UCAV Recovery System 5. Explosive Weapons—Dialable Effects Warhead - Adjustable Fusing 6. High Energy Density Material (HEDM) Weapon - High Performance Explosive - Penetration Casing 7. Guns/Cannons—Electromagnetic Railgun 8. Guns/Cannons—Million-Rounds-Per-Minute Gun ("Metal Storm") - Pre-Packed Barrel 9. Kinetic Energy Weapons—Hypervelocity Rod 10. Kinetic Energy Weapons—Railgun Projectiles 11. Optical Energy Weapons—Adaptive Laser Optics - Deformable Mirror - Wavefront Sensor 12. Optical Energy Weapons—Chemical Oxygen Iodine Laser (COIL) - Laser Cavity - Supersonic Nozzle 13. Optical Energy Weapons—Electrically Driven, Solid-State, High-Energy Laser - Amplifier - Laser Cavity - Laser Diode Array 14. Propulsion—Electromagnetic/Pulsed Plasma Thruster 15. Propulsion—Hypersonic Weapon Propulsion System 16. Propulsion—Miniaturized UAV Turbine Engine 17. Propulsion—Scramjet - Combustion Chamber - Nozzle 18. Propulsion—Multi-Legged UGVs Propulsion System - Power Board - Robotic Leg	19. RF Energy Weapons—Suitcase-Sized, High-Powered Electromagnetic Pulse (EMP) Device - Explosively Pumped Flux Generator - High-Power Spark Generator 20. RF Energy Weapons—Ultra-Wideband Pulse Power HPM Device - Compact, Efficient, High-Power Pulse Power Driver - Compact, High-Peak-Power, or High-Average-Power HPM Source 21. Special Purpose Weapons—Polymer Interferant 22. Special Purpose Weapons—Self-Propagating High-Temperature Synhesis (SHS) Device - Ignition Source - Metal and Inter-Metallic Nano-Powder 23. Structures—Hypersonic Transatmospheric Vehicle, High-Stress-Tolerant Structural Materials - Boron Epoxy Composite - Graphite Epoxy Composite - Titanium Metal Matrix 24. Structures—Multifunctional Structure 25. Structures—Small-Caliber Projectile Control Surfaces 26. Structures—Ultra-High-Temperature Materials - Carbon Components - Ceramic Matrix - High-Temperature Polymers 27. Weapons Fuses—Prerelease Selectable Penetration Weapon Fuse - Precision Accelerometer 28. Weapons Fuses—Void Detection Fuse 29. Weapons Guidance and Control—Acquisition, Tracking, and Pointing Laser 30. Weapons Guidance and Control—Aiming/Lock-On Laser 31. Weapons Guidance and Control—Jitter and Vibration Management System - Fast Steering Mirror - Passive Isolator

This assessment identified a total of 274 companies, laboratories, and universities involved in the 61 technologies and components investigated. This supplier list is summarized in Appendix C. While the summary does not include every supplier in

[19] Components associated with the technologies are indented.

these industrial areas, it illustrates the overall strength of the domestic FA industrial base. It also indicates the strength of foreign suppliers in this industry segment.

A by-product of this analysis has been the successful application of a methodology that uses the Joint Staff's joint functional concepts as a basis for focusing the industrial base on those technologies likely to continue to assure the U.S. lead in high technology weapons systems. In *DIBCS BA* and *DIBCS C2,* our systematic assessment indicated that 82 percent and 74 percent, respectively, of warfighting capabilities associated with Battlespace Awareness and Command and Control functional concepts were *BA/BWA*. In FA, *BA/BWA* capabilities were assessed to be on the same order—76 percent. Hence, the use of the joint functional concepts and our translation of these concepts for our DIBCS assessments should help Department policies effectively focus the industrial base on these important *BA/BWA* capabilities. Meeting this challenge will ensure that the products for the 21st century military operations envisioned in the joint functional concepts are available to the warfighter.

CRITICAL INDUSTRIAL AND TECHNOLOGY DEFICIENCIES AND ISSUES

Of the 212 critical technologies identified, initial assessments covered 32 technologies. Of these 32 technologies, we assessed that the industrial base supporting 21 of these is sufficient. We assessed the industrial base for six technologies as being potentially insufficient:

- GPS-Guided Small Diameter Bomb (SDB);
- Chemical Oxygen-Iodine Laser (COIL);
- Pulsed Plasma Thruster;
- Hypersonic Weapon Propulsion System;
- Self-Propagating, High-Temperature Synthesis Device; and
- Small Caliber Projectile Control Surfaces.

Two technologies require further assessment at the appropriate classification level, and one was determined to be too early in its development (conceptual idea only) to warrant inclusion at this time. Another technology, Hypervelocity Rod, is in concept development. The Air Force acknowledges it has a long-term program in Hypervelocity Rod research, and given U.S. leadership in railguns, we are confident this technology will develop apace. At this time, it warrants no further action.

As a by-product, the *DIBCS FA* methodology also identified potentially disruptive technologies not planned for use by U.S. warfighters that represent capability breakthroughs which could leapfrog or enhance existing *BA/BWA* capabilities. In the warfighter's interest, we have placed two such technologies on a "Watch List" for further consideration. These "Watch List" items—potentially to be joined by "Watch List" items for Protection and Focused Logistics—could demonstrate the utility of the Industrial Base Investment Fund concept we have been developing and which will be discussed in Part III.

FORCE APPLICATION “WATCH LIST” TECHNOLOGIES

Million-Rounds-Per-Minute Gun (“Metal Storm”) and Electro-Hydraulic Cavitation Devices are the two FA “Watch List” technologies as shown below.

FORCE APPLICATION TECHNOLOGY “WATCH LIST”

Technology	Industrial Base Sufficiency Analysis			Rationale (for associated remedies, see page 53)
	Domestic Sources	Foreign Sources		
Million-Rounds-Per-Minute Gun (“Metal Storm”)	0	1		Breakthrough technology, one-of-a-kind projectile weapon. Developed by Australia. Actively being promoted to DoD and Department of State for military use and Embassy protection. Could provide adversaries a force multiplier capability. Appears U.S. government is not buying. No domestic suppliers.
Electro-Hydraulic Cavitation Device	1	0		Breakthrough technology for sea warfare, developed via SBIRs but apparently not being adopted by USN. Would provide an adversary the capability to compromise U.S. sea warfare capabilities.

Sources: Booz Allen Hamilton and ODUSD(IP)

Million-Rounds-Per-Minute Gun (“Metal Storm”). In the “Defeat Land, Sea, or Air Targets with Projectiles” *BA/BWA* warfighting capability, we identified technologies such as electromagnetic railgun, hypervelocity rods, and railgun projectiles. U.S. sources have demonstrated railgun prototypes and railgun projectile component technology; hypervelocity rod is in early stage concept development.

However, none of these technologies have the rate-of-fire capabilities of the Million-Rounds-Per-Minute gun developed by Metal Storm, Ltd. This technology has no known equivalent and can provide an electronically variable burst rate of fire, from conventionally slow to rates in excess of one million rounds per minute—rates beyond U.S. capabilities. We assess this technology and its applications to the railgun and hypervelocity rods as being ahead of those associated with current U.S. capabilities. Across numerous applications, the technology incorporated in the Million-Rounds-Per-Minute Gun could accelerate and synergize U.S. science and technology initiatives in the field of projectile weaponry. From an operational perspective in the JFAFC area, it would provide an enhanced capability for special operations, and for destroying adversary command stations and key power grid sources from either an airborne or land platform. It could also prove valuable for ship defense, mine clearing, and other defense applications. Conversely, were this technology to proliferate, it is not clear that air, land, and sea-based counter-measures exist which could defeat this system.

The sole source of this foreign technology, the force multiplier effect of this technology, and the lack of U.S. warfighter “pull” for the technology warrants its inclusion as a “Watch List” item—and as a potential candidate for the Industrial Base Investment Fund. We recognize that this is not a new technology and may not be optimized for

U.S. operational employment; however, the Department may want to take one last opportunity to appraise its technological value.

Electro-Hydraulic Cavitation (EHC) Device. EHC Device technology being produced by Tetra Corporation is a critical technology to defeat surface and subsurface sea targets (a *BA/BWA* capability). A combination of EHC with Tetra's proprietary focusing technology would use arrays of high-power, spark-gap projectors to create very intense, focused pressure waves that could actively track an incoming submerged target, and then increase power to destroy its structure or sensor systems. Such a system could provide U.S. Navy systems both an offensive and defensive capability. In addition, were this technology to proliferate, it could be used to defeat U.S. underwater sensor system capabilities.

At present only Tetra Corporation has the combination of EHC technology and focusing technology for military applications. Given the technology's capability to destroy/degrade underwater sensor systems, we believe this technology belongs on the "Watch List."

These technologies represent breakthroughs having the potential to significantly alter particular warfighting domains. The immediate concern is that they have no U.S. warfighter sponsored "pull" toward a specific application and no proven counter-measures. If such technologies are allowed to proliferate, they possess the potential to be disruptive to U.S. warfighting advantages—hence, the need for such a "Watch List." The "Watch List" is being put in place as a DIBCS feature to highlight the existence of such technologies to senior military leadership for inclusion in future capability planning or Industrial Base Investment Fund initiatives—and to prevent the proliferation of such potentially disruptive technologies.

ISSUES IN THE FA INDUSTRIAL BASE

We found sufficient industrial base capabilities for 21 of the 32 priority critical technologies.[20] Industrial capabilities available for these technologies, and 18 of the associated critical components, are summarized on the following page.

[20] The primary objective of this study is the identification of the array of capabilities and technologies in Force Application and a process for assessing them and addressing deficiencies. Resources limited the number of critical technologies assessed to 32 of the most pressing, but issues in the remaining technologies will be addressed. The ODUSD(IP) staff will continue to evolve the baseline established in this study, updating the capability framework and critical technology lists, performing additional assessments of critical technologies, and identifying any additional industrial base issues for consideration by Department decision-makers.

21 Priority Critical Technologies with Sufficient Industrial Base Capabilities[21]

1. Computer Logic Bomb
2. Mobile Codes
3. Common Automated UAV/UCAV Recovery System
4. Dialable Effects Warhead
   - Adjustable Fusing
5. High Energy Density Material (HEDM) Weapon
6. Electromagnetic Railgun
7. Railgun Projectiles
8. Adaptive Laser Optics
   - Deformable Mirror
   - Wavefront Sensor
9. Electrically Driven, Solid-State, High-Energy Laser
   - Amplifier
   - Laser Cavity
   - Laser Diode Array
10. Miniaturized UAV Turbine Engine
11. Scramjet
    - Combustion Chamber
    - Nozzle
12. Multi-Legged UGVs Propulsion System
    - Power Board
    - Robotic Leg
13. Polymer Interferant
14. Hypersonic Transatmospheric Vehicle, High-Stress-Tolerant Structural Materials
    - Boron Epoxy Composite
    - Graphite Epoxy Composite
    - Titanium Metal Matrix
15. Multifunctional Structure
16. Ultra-High-Temperature Materials
    - Carbon Components
    - Ceramic Matrix
    - High-Temperature Polymers
17. Prerelease Selectable Penetration Weapon Fuse
    - Precision Accelerometer
18. Void Detection Fuse
19. Acquisition, Tracking, and Pointing Laser
20. Aiming/Lock-On Laser
21. Jitter and Vibration Management System
    - Fast Steering Mirror
    - Passive Isolator

Source: Booz Allen Hamilton and ODUSD(IP)

[21] Components associated with technologies are indented.

The following two tables summarize the six industrial base issues identified in this assessment: the first dealing with "Engagement Maneuvering" issues and the next with "Engagement" issues. Each technology and its link to warfighter capabilities is described in some detail followed by an explanation of why industrial base sufficiency is or may become an issue.

ISSUES IN THE FORCE APPLICATION INDUSTRIAL BASE: "ENGAGEMENT MANEUVERING"

DIBCS FAFC	Technology	Industrial Base Sufficiency Analysis			Rationale (for associated remedies, see page 55)
		Domestic Sources	Foreign Sources		
Engagement Maneuvering	Pulsed Plasma Thruster	2[22]	0	Yellow	This technology offers a unique approach to space maneuvering (pointing). It is maturing, with two companies in development and a number of companies and universities in research. The United States has a significant lead but only two domestic sources.
	Hypersonic Weapon Propulsion System	1	1	Yellow	Propulsion system for long range air-to-ground and surface-to-surface weapon applications. Limited market size not likely able to support more than one supplier at this time. The United States is even with the rest of the world —needs to lead.
	Small Caliber Projectile Control Surfaces	0[22]	0	Yellow	Early technology development, only two domestic researchers which lead the world. This supply base may be adequate at this time—particularly with no identified foreign competition—but the situation could change quickly and should therefore be closely monitored.

Source: Booz Allen Hamilton and ODUSD(IP)

Pulsed Plasma Thruster (PPT). Electromagnetic PPTs will provide lightweight, durable, continuous, on-orbit maneuvering capability. By introducing a low mass propulsion solution, this technology will enable complex space missions and precision space asset pointing. This is important to the support of FA capabilities to maneuver space-based assets into position.

U.S. technological leadership is key to developing and producing PPTs to provide these FA capabilities. Two domestic suppliers are producing PPT technology. Several other companies are conducting research and development on similar technologies. The United States also has several academic institutions and research laboratories actively studying PPTs. Even though Russian and European research institutes began work on PPTs at the same time as the United States in the 1960s, we identified little foreign activity. The Department should closely monitor the industrial base for this technology as it continues to mature.

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[22] Additional R&D underway, not yet in production.

Hypersonic Weapon Propulsion System. Weapons cannot achieve hypersonic velocity without high-energy composite propellants, advanced composite materials, and improved avionics and aerodynamics. The resulting hypersonic propulsion systems will reduce shooter-to-target engagement times, thereby minimizing countermeasure response times and shortening the "kill chain" for time-sensitive, perishable targets. Although we assess U.S. technological leadership as even with the rest of the world for the hypersonic rocket propulsion systems, only one U.S. and one foreign researcher provide integrated hypersonic weapons platforms. One U.S. supplier may not be sufficient, given the potential desire to adapt this technology to multiple weapons propulsion concepts.

Small Caliber Projectile Control Surfaces. Small-caliber control surfaces—or "smart bullets" technology—provide the foundation for the capability to re-direct a projectile in flight to enable greater accuracy, defy normal ballistic trajectories, or follow a moving target. This technology could decrease costs by reducing the ammunition quantities necessary in engagements. It could also improve the effectiveness of the individual warfighter in combat and reduce the potential for unintended collateral damage. U.S. technology research leads the rest of the world for small caliber projectile control surfaces. But because of the immaturity of the technology, there are no domestic suppliers making this product. Lockheed Martin and Auburn University are actively involved in R&D. We identified no foreign suppliers of this technology; however, several foreign manufacturers of medium and large caliber projectile control surfaces could continue to improve and develop technology for use with small-caliber munitions. The Department should monitor the industrial base and be prepared to expand the base as the technology matures.

ISSUES IN THE FORCE APPLICATION INDUSTRIAL BASE: "ENGAGEMENT"

DIBCS FAFC	Technology	Industrial Base Sufficiency Analysis			Rationale (for associated remedies, see page 55)
		Domestic Sources	Foreign Sources		
Engagement	GPS-Guided Small Diameter Bomb (SDB)	1	0	Yellow	Breakthrough technology applicable to targets requiring low yield and high precision. United States has significant lead but opted for one supplier. A potential second source not continued after 2003 program down-select—policy on sustaining competition needs to be reviewed.
	Chemical Oxygen-Iodine Laser (COIL) (High/Low Power)	2 High 3[23] Low	0 High 3[23] Low	Yellow	New way of defeating air targets. Two suppliers appear adequate for weapons-class chemical lasers, with a number of U.S. and foreign entities working similar technologies at lower power. United States leads but foreign research could be applied to higher power weapon system—further monitoring warranted.
	Self-Propagating High-Temperature Synthesis Device	1[23]	0[23]	Yellow	Innovative technical concept in the area of explosives. One supplier (13 employees) is probably not sufficient if U.S. military desires to move technology to production. The United States has a tenuous lead; one foreign research source identified. This situation warrants monitoring.

Source: Booz Allen Hamilton and ODUSD(IP)

[23] Additional R&D underway, not yet in production.

GPS-Guided Small Diameter Bomb (SDB). The GPS-guided SDB is a new weapon that acts as a force multiplier with increased accuracy and with less destructive power than current systems, such as the 2,000-pound Joint Direct Attack Munition (JDAM); and lends itself to internal carriage. At this time, the United States has a significant lead in the development of this technology, but only a single source—Boeing.

GPS-guided SDBs improves the application of force to concentrated or localized area engagements. The combination of precision guidance and smaller yields will minimize collateral damage in urban areas or on targets close to civilians or other non-combatants. It also will act as a force multiplier by increasing the number of weapons per sortie. This capability will also enhance targeting to support ground operations.

When the Department downslected to Boeing, it eliminated Lockheed Martin, creating a single source and forfeiting the associated innovation and competition that multiple sources provide. We recommend the Department reconsider this single source acquisition strategy.

Chemical Oxygen-Iodine Laser (COIL). Of the multitude of potential lasers, COIL is the only high-powered laser currently being operationalized, and therefore the only laser facing industrial base sufficiency issues. COIL is earmarked for airborne laser applications and is a modular, chemical, continuous-wave, high-energy, electronic transition laser. The COIL laser applies thermal energy to an area of the selected target, causing the target structural materials to fail or igniting internal combustibles.

The U.S. leads the world in weapons-class, high-powered COIL lasers.[24] However, there are only two domestic sources of high-powered COIL lasers: Northrop Grumman and Boeing. Other U.S. companies and U.S. military laboratories and universities continue research in high-powered chemical lasers. Researchers in Israel, the Czech Republic, Russia, Japan, and Germany also are conducting research on COIL lasers for both military and industrial uses. We identified no foreign suppliers for high-power COIL lasers. With only two U.S. sources for this technology, the Department should continue monitoring the development of this industrial base.

Self-Propagating High-Temperature Synthesis Device. A warhead concept invented in Russia in 1988, self-propagating high–temperature synthesis (SHS) warheads create a cloud of highly-reactive metallic or inter-metallic nano-particles, which produce intense blast and thermal pulses up to 9,000 degrees Fahrenheit, as well as a disabling radio frequency effect. While this concept has advantages over existing weapons, the breakthrough lies in the multi-effects feature of the weapon (intensely energetic blast, thermal and radio frequency effects). Such technology will give dismounted soldiers, special operations squads, or small delivery vehicles unprecedented firepower.

One small, 13-employee U.S. company provides the United States leadership in SHS warheads. In addition, one university is conducting research in this area. Europe,

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[24] Commercial applications for COIL lasers may develop in the long term as the technology improves and becomes cheaper and easier to build.

Japan, Singapore, and South Korea are working on commercial applications of SHS in an international R&D consortium. Weaponized SHS work seems to be confined to the United States, Russia, and China for the time being. Because of the tenuous industrial base for this technology, the Department should monitor the industrial base and be prepared to expand the base as the technology matures.

The Department should continue to closely monitor the Force Application *BA/BWA* warfighting capabilities, associated priority critical technologies, and industrial base capabilities—and be prepared to intervene when critical industrial base deficiencies or potentially disruptive technologies are identified. The following part of this report assesses the sufficiency of program management and acquisition tools which can remedy such issues. It also outlines on-going activities designed to move the acquisition community to capability-based acquisition oversight processes, as well as initial concepts for a new technology transition mechanism—the Industrial Base Investment Fund. Discussion of remedies to issues identified begins on page 55.

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PART III

POLICY IMPLICATIONS

As the strategic environment, the industrial base, and operational requirements have changed, the Department is developing new strategies to leverage technology and industrial base innovation in order to deliver critical capabilities to the warfighter. These integrated, capabilities-based approaches will drive acquisition decision-making, force changes in the Department's corporate processes, and challenge program managers and the Department to plan for innovation and to inject it more rapidly.

THE NEED FOR PROGRAM MANAGER FLEXIBILITY

The functional capability construct requires increased emphasis on program managers' ability to deliver critical capabilities to the warfighter that leverage technology advances. The Department's acquisition policies have not stood still in the face of change. Programs have adapted "on the fly" and newer programs have often created entirely new program management constructs, giving us new tools as we move forward.

HISTORICAL PERSPECTIVE

The 20th century history of the Department of Defense was dominated by the Cold War. The threat was consistent and sophisticated, and the expected mode of battle changed only gradually. The prosecution of this threat fostered the development of a wide variety of platforms and weapons in a steady progression of high-profile programs.

For the acquisition community, this environment created demand for advanced platforms and weapons. The resulting systems were complex, often incorporating myriad emerging technologies. The development phase of these programs could run many years, and production typically spanned decades. Most programs were supported by large budgets. Not surprisingly, this was also the era of the dominating program manager, working in a highly platform-oriented organization. This arrangement worked well, producing the highly-capable systems that helped win the Cold War.

One of the best examples of this platform-dominated acquisition environment was the F-16 program and Lieutenant General (retired) James Abrahamson, the program director from 1976 to 1980. Known as a charismatic leader, he ran the program in a hands-on manner, and was not afraid of conflict with the contractor. The program was a success by any measure. Over 4,000 aircraft have been produced on five production lines for 19 nations, and the F-16 is still in production today. As well as serving in the Cold War, F-16s have been dominant performers in many conflicts, flying for the U.S. Air Force and for several foreign air forces.

The value of the programs created in this era did not end with the Cold War. As the Department pursues transformational warfare, it has seen ground-based warfighters giving detailed targeting information directly to F-16s, as well as to F-15s, F/A-18s,

B-1s, B-2s, and even B-52s—all products of its platform-centric Cold War past. These legacy systems are robust and adaptable platforms, and make today's rapidly changing transformational concepts possible. As the Department looks forward, it must develop acquisition strategies that create equal success in the new environment and provide future warfighters with the capabilities they will need, for roles yet unknown.

> *"Today's net-centric warfare is only possible because of the highly capable platforms we've developed in the past."*
>
> - *Gen Lawrence Welch, USAF (Ret), Former Chief of Staff, U.S. Air Force*
>   *August 16, 2004*

The threats faced in the 21st century are diverse, ranging from today's terrorist organizations unaffiliated with a nation-state, to potential near-peer adversaries. Where the Department faced only one consistent threat during the Cold War, today it faces a group of threats, much different than those imagined a few years ago, and likely soon to be different than those imagined now.

The acquisition environment affecting programs has also changed since the days of the Cold War, and will continue to change. It was once acceptable to view the world in a Service stovepipe and to think only of platform solutions. This mindset would leave the Department behind on the transformation path, unable to meet the evolving threat. Accordingly, the Department is moving to capabilities-based requirements generation and acquisition processes.

> *"It is pretty clear [the requirements process] is broken, and it is so powerful and inexorable that it invariably continues to require things that ought not to be required, and does not require things that need to be required."*
>
> - *Secretary of Defense Donald Rumsfeld to General Peter Pace, Vice Chairman, Joint Chiefs of Staff*
>   *March 2002*

The Department has attacked these challenges by creating the Joint Staff's Joint Capabilities Integration and Development System (JCIDS) to determine what warfighters require. It also envisions new acquisition oversight processes. These processes would provide an increasingly capabilities-based framework for evaluating legacy systems and initiating new programs. Where the existing Defense Acquisition Board (DAB) acquisition oversight process focuses on single-program metrics, these new acquisition oversight processes would give the Department the broader functional capabilities. This, in turn, allows the Department to evaluate interactions among systems, identify issues common to multiple programs, and measure progress toward meeting broad capability needs.

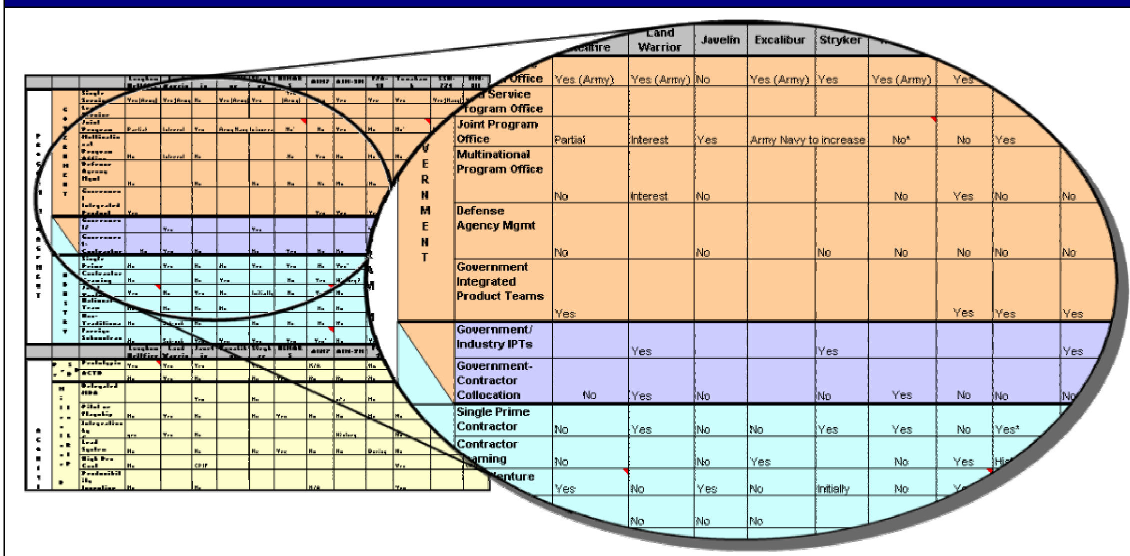
These changes mean that program managers cannot manage in the way the Lt Gen Abrahamson did. Today's program managers have to use new approaches and combine the existing tools in new ways to develop capabilities that will collectively meet future warfighters' needs. Acquisition oversight must also be conducted to assess and synchronize capabilities' ability to collectively meet these needs.

PROGRAM MANAGEMENT TODAY

Program managers must have a robust set of acquisition tools with which to work, and they must use these tools flexibly, tailoring them to their changing requirements. To assess the use of these acquisition tools, we examined FA programs from two perspectives. First, we surveyed a sample set of programs and evaluated program management and acquisition strategy (PM/AS) tools being used within those programs. Second, we studied a smaller group of programs to see how they have successfully used the available tools to adapt to changing circumstances.

We first listed the acquisition tools available to program managers, and determined which were used by each program. This survey was designed to tell us whether the newer acquisition tools were widely applied, and whether programs were demonstrating flexibility by using different tools to match unique circumstances. An excerpt from the taxonomy produced by this analysis is below.[25]

PM/AS TAXONOMY EXCERPT



Source: Institute for Defense Analyses

The survey showed that program managers in the FA sector are indeed making flexible use of the tools provided to them, and that this bodes well for these and future programs as they begin to operate in the functional capability context. Some techniques, such as Low Rate Initial Production (LRIP), are used by nearly every program. LRIP offers the opportunity to maintain flexibility before moving to full production—effectively keeping the *weapon system design*[26] portal open and allowing programs to incorporate the latest technology, respond to changing warfighter requirements, and synchronize with other programs within their functional capability sector.

[25] See Appendix E for complete program management and acquisition strategy taxonomy.
[26] The portals and levers construct related to program management in acquisition strategies was first developed *DIBCS BA* and is enclosed in Appendix D.

Spiral development, though not yet universally applied, is also widely utilized. The Army is particularly forward-leaning here, applying spiral development in five of the six programs surveyed. Spiral development, like LRIP, maintains flexibility: it keeps portals open so that programs can adapt later in their acquisition process. This is critical as programs begin to operate in the dynamic functional capability environment where the Department desires rapid infusion of new technologies and capabilities.

Several programs reported use of the Lead System Integrator (LSI) concept. LSI is in some ways an extension of what prime contractors have always done, integrating the myriad subsystems that make up complex systems such as tactical aircraft, aircraft carriers, and submarines. However, the Future Combat System (FCS) applies this concept on a larger scale than any previous program, in large measure assigning what has been the role of the government to the LSI. Properly managed, the broader application of LSI should facilitate wide company participation in technology insertion, capability development, and system-of-systems architecture, improving the Department's ability to provide the capabilities warfighters require.

To ensure prime contractors do not shut out innovative subcontractors in favor of doing the work in-house, the USD(AT&L) issued policy guidance[27] requiring program managers and contracting officers to retain both insight into the subcontractor selection process and an ability to influence that selection. For example, when establishing the contract fee structure, program managers and contracting officers are encouraged to give more value to the contractor's effective use of competition throughout the life of the program. In fact, the program manager may require that certain subcontracts be let only after explicit DoD approval, if there is determined to be a potential for bias in subcontractor selection and the potential bias cannot be adequately mitigated. Industry initiatives to enhance the Department's ability to "plug and play" systems—regardless of source—are also important enablers in this new capabilities-based acquisition environment.

> *"Industry initiatives such as the Network Centric Operations Industry Consortium will ensure weapon systems of the future can communicate with each other enhancing this mutually supportive, capability-based behavior of program managers in that—if these industry standards take hold—many of force application's technology and capability building blocks will indeed be interchangeable."*
>
> - *Suzanne D. Patrick, Deputy Under Secretary of Defense for Industrial Policy October 2004*

Our survey also showed that program managers are scanning the available acquisition tools and choosing the ones useful to them, tailoring a toolbox that works for their programs. Prototyping, for example, is a useful way to test and verify new concepts, but is more practical for tactical missiles than for ships. Consequently, the Army is using prototyping on four of the six programs surveyed, while the Navy limits prototyping to the subsystem level. Similarly, Advanced Concept Technology Demonstrators (ACTDs)

[27] Wynne, Michael W., Memorandum for Secretaries of the Military Departments, Service Acquisition Executives, and Directors of Defense Agencies, July 12, 2004.

are an excellent way to get capability quickly, as demonstrated by Predator and Global Hawk. But ACTDs can increase risk as they push new technology to the warfighter. They are most practical for systems with smaller unit costs, where the required investments are smaller, and the risk/reward ratios are more favorable. We wouldn't expect to see wide application of ACTDs to the large unit cost/small quantity systems in this group, such as ships—and don't. Instead, the smaller Land Warrior, the High Mobility Artillery Rocket System, and the Tomahawk warhead programs applied the concept.

Overall, our survey showed that program managers are applying the *program management* lever through flexible use of acquisition strategies. This will allow powerful portals to remain open for a greater portion of the acquisition process, as they must if the Department is to have acquisition tools that are adaptable and responsive to functional capability requirements. We evaluated four programs to determine how program managers use PM/AS tools for mature programs and structure new programs differently than did their predecessors.

AMRAAM

AMRAAM EXAMPLE

- Cold War genesis
- Leader-follower contracts originally maintained competition
- Product improvements have controlled cost since merger of Hughes/Raytheon

Few programs have seen more change during their life cycle than the Advanced Medium Range Air-to-Air Missile (AMRAAM). The program began as a study conducted in 1975 at the height of the Cold War and reflected the defense environment of the time.

From a requirements viewpoint, AMRAAM was typical of the period. It was designed as an improved beyond-visual-range air-to-air combat missile to replace the AIM-7 Sparrow, which performed a similar function. AMRAAM was intended to meet the well-known Soviet threat, and its requirements centered on the fairly narrow specification to engage air-to-air targets at a range of 20+ miles. Also typical of the time, the program was to be very large, for a total of 25,000 missiles not including foreign military sales, with production rates of 3,000 per year. From a technology viewpoint, AMRAAM was also typical in that it was enabled by a particular defense-specific state-of-the-art technology. That technology allowed fabrication of a transmitting radar small enough to fit inside the narrow constraints of an air-to-air missile body.

The program's initial design took advantage of its environment, and in a pattern repeated by many programs, adapted known strategies to meet unique needs. To make best use of the broad industrial base and the large projected order quantities, the program applied the *PM/AS* lever to produce benefits in several portals. The program manager established a leader-follower arrangement with competition in both the development and production phases. But the competition was not a simple hands-off winner-take-all approach. When costs were higher than hoped, the program used the

PM/AS lever to enable investment in cost-saving and reliability improvements. The program manager also incentivized cost-saving improvements by the contractors, giving a share of the savings to the improvement's originator, no matter which factory produced the missiles. Because maintenance of future competition was desirable, the Department also established a minimum number of missiles to be awarded to the "losing" or second-place producer each year, allowing them to sustain production.

Even before reaching full production, AMRAAM faced a shift in the ground beneath it. The Cold War ended, production quantities were reduced, and a wave of mergers began in the defense industry. Where production quantities were originally planned to be 3,000 per year, actual U.S. procurement only once exceeded 1,000, and was more often less than 500, for a total to-date of under 9,000—far short of the planned 25,000. Where five competitors originally bid for AMRAAM and a leader-follower arrangement with Hughes and Raytheon was once possible, Raytheon is now the only supplier of air-to-air missiles.

The program adjusted to these changes. Production improvement and cost reduction programs helped control costs despite declining quantities. As quantities dropped to a level where dual sourcing was no longer practical, the program manager began preparations to work with a Raytheon/Hughes joint venture. When Raytheon's acquisition of Hughes overtook this plan, the Department worked with the Department of Justice to make a long-term pricing agreement a condition of the acquisition, controlling price as the program moved to a sole source environment.

By structuring the acquisition strategy to suit the requirement, and then adjusting as needed, the AMRAAM program has continued to succeed through a period of dramatic structural change. Competition and product improvements have helped control costs while improving quality. The program has been in production for over 20 years, has included 27 countries, and will be a standard weapon on future air combat systems, including the JSF, well into the 21st century.

F/A-18

Changes have challenged the F/A-18 program as well. Like AMRAAM, the F/A-18 program began at the height of the Cold War. Also like AMRAAM, it replaced existing systems—the A-7 and F-4 aircraft. The F/A-18's multi-mission capabilities allowed it to execute all the missions originally performed by both the A-7 and F-4 aircraft. And like AMRAAM, planned quantities were very large. Unlike AMRAAM's evolutionary improvements, the F/A-18 program introduced revolutionary innovation with a new variant—the F/A-18E/F. The post-Cold War environment and the A-12 cancellation made these changes within the Navy and McDonnell Douglas necessary.

F/A-18 EXAMPLE

- Cold War genesis
- Product improvement through introduction of F/A-18 E/F
- Managed by Integrated Product Teams, multi-year procurements
- Continuous technology improvements

The program responded by applying the *PM/AS* lever at several portals—changing the way the aircraft was conceived, how the program was organized, and how the system was built. Unlike the A-12 and many Cold War weapons, the F/A-18E/F program carefully managed requirements to minimize cost and schedule risk. Although it included many technological advancements, its success did not rely on the maturation of a particular state-of-the art technology, as AMRAAM did. Technology maturity, including manufacturing technology, was an important consideration in the original design of the F/A-18E/F, and this was critical to the ultimate cost, schedule, and performance success of the program. The aircraft design included reduced observability, but the program manager balanced this requirement against cost with an eye to the likely threat. Aerodynamic performance was to match that of the F/A-18C/D, though greater performance was certainly possible.

From the start, the Navy organized the program using Integrated Product Teams (IPTs) in the government offices, in the contractor offices, and in government/contractor interactions. The F/A-18 program was ahead of its time, implementing IPTs years before the Department directed its programs to do so. A smooth working relationship between government and contractor teams is still cited today as a hallmark of the program.

McDonnell Douglas—now a wholly-owned subsidiary of Boeing—also made dramatic changes in how the aircraft would be built. It decided to build the F/A-18E/F in a new building, shedding the burden of existing methods of production. Its strong commitment to optimize efficiency and minimize production costs resulted in an airframe with 42 percent fewer parts than the F/A-18C/D.

The Department also made dramatic changes in acquisition strategy and program oversight. It took advantage of multi-year procurements (MYPs) to reduce acquisition cost. For instance, prices in the second MYP were more than $1 billion less than those forecasted for year-to-year procurements over the same time period. The F/A-18E/F program was also an early leader in the application of the Integrating IPT and Overarching IPT construct to streamline the acquisition oversight process. Just as importantly, the F/A-18E/F program fully embraced Cost as an Independent Variable to ensure program costs were treated with the same discipline as any other system attribute. Other acquisition management initiatives taken with the F/A-18E/F program include a program level risk management initiative with participation by all stakeholders (the Program Office, government functional experts, and the contractors); an Integrated Test Team approach to developmental testing; early involvement of the operational test community; and a highly disciplined approach to Earned Value Management. Finally, the F/A-18E/F program was one of the first major acquisition programs to embrace a performance-based system specification. The Department recognized these significant acquisition management achievements in 1996 by presenting the F/A-18E/F program with the first U.S. Department of Defense Acquisition Excellence Award, later designated the David Packard Excellence in Acquisition Award.

Like AMRAAM, the F/A-18 program has had to adjust to change. The Department reduced F/A-18E/F planned quantities early in the program when the Marine Corps opted to acquire the JSF and not the F/A-18E/F and the Navy reduced its buy as well. The challenge of inserting new technology into an existing program has also been managed well. For example, the program is in the process of integrating an Active Electronically Scanned Array (AESA) radar. The program is also developing a "G" variant to provide electronic warfare capability to be integrated into the existing production program. These initiatives require careful contracting and risk management.

Future Combat System

The Future Combat System (FCS) is an entirely new type of program. Where AMRAAM and F/A-18E/F were systems that looked much like their predecessors, FCS will create something nothing like systems we currently operate. It will make extensive use of the *PM/AS* lever across the program life cycle. Where the Army previously procured systems to fight large tank battles in specific terrain against a known adversary, FCS will be built to provide a host of specific capabilities to perform a wide variety of missions against a full spectrum of threats, from urban to full spectrum warfare, in unknown terrain. Further, the precepts of network-centric and maneuver warfare put a premium on speed, flexibility, interoperability, and networking. FCS will be more complex than any previous Army program and require new integration skills.

FCS EXAMPLE

- Networked system-of-systems—new way of business
- LSI management structure

The program's structure borrows many existing tools, but creates a structure as unusual as FCS's requirements. To maintain flexibility during the creation of this revolutionary system, the program takes Other Transactional Authority (OTA) mechanisms created for relatively small Defense Advanced Research Projects Agency (DARPA) programs, and expands then to the multi-billion dollar FCS development program. Like other programs we've examined, FCS adapts the tool to its needs, while complying with Federal Acquisition Regulation and Defense Federal Acquisition Regulation Supplement provisions.

Because the program will be extraordinarily complex, and truly a system-of-systems, the contracting team led by Boeing and SAIC will be an LSI. This expands the prime contractor's responsibility from the traditional integration and performance of subsystems to responsibility for multiple systems, including ground vehicles, air vehicles, and unattended ground sensors. Again adapting an existing tool, the program aimed the *PM/AS* lever directly at the *make/buy* portal by inserting protections against biases in subcontractor selection, subsequently reiterated for all Department programs.[28] The Army Acquisition Executive, or designee, must approve all make/buy decisions for hardware or software at the system or subsystem level. The FCS program manager, or designee, has reserved the right to approve make/buy decisions for all

[28] Wynne, Michael W., Memorandum for Secretaries of the Military Departments, Service Acquisition Executives, and Directors of Defense Agencies, July 12, 2004.

other items. Finally, the Department is permitted to direct work to a specific contractor if it disagrees with an LSI subcontractor selection.

Because the FCS is taking part in and will to some extent guide a dramatic change in Army concepts of operation, government and contractor personnel must work together especially closely. The program recognizes this by not only instituting IPTs, but by codifying them in the OTA agreement. This will also allow management of the extensive spiral development process that is key to the program.

The FCS program will be particularly challenged by extensive interoperability requirements, including interaction with systems as different as the JSTARS ground surveillance aircraft, the GCCS command and control system, the Land Warrior combat system, and the Shadow UAV. It will require an extraordinary amount of software development, often a schedule driver for complex programs. And FCS is taking the largest leap of any current program into the world of capability-based requirements, transformation, and network-centric warfare. FCS is employing existing *PM/AS* tools, adapting them, and creating new ones. Program lessons learned will inform future acquisition decisions and increase the potential for other acquisition program successes.

Precision Guided Munitions

PGM EXAMPLE

- PGM sector has become highly consolidated
- Advanced technology has made PGMs highly sought after weapon

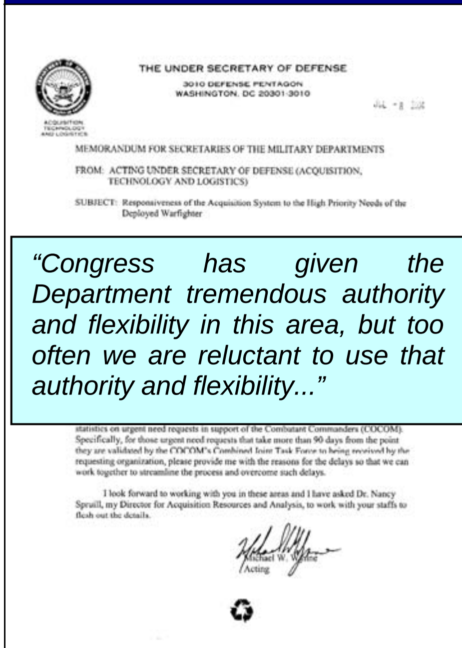
Not only are individual programs adapting to change, but often entire sectors as well—and none more so than the Precision Guided Munition (PGM) sector. Requirements, budgets, and quantities have changed, as they have for most sectors, and the structure of the industry and the underlying technology have dramatically changed as well.

Few areas of the industrial base have seen more consolidation than PGMs. In 1990, 12 domestic prime contractors were active participants, while only Raytheon, Boeing, and Lockheed Martin remain today. This consolidation has made it critical for the government to manage competition, often using creative concepts, such as the commercial pricing strategy of Joint Air-to-Surface Standoff Missile (JASSM).

Technology has also dramatically changed the PGM sector. The terrain mapping guidance packages in the earliest cruise missiles drove a large part of the system's cost. Today, GPS and more capable infrared systems have helped make precision guidance—once a luxury for a few high-priority systems—commonplace. Used on less than 10 percent of the missions in Operation Desert Storm, coalition forces used PGMs on more than 75 percent of the missions in Operation Iraqi Freedom. Higher production quantities, in turn, have reduced average unit costs, enabling more applications, such as precision guidance in artillery ammunition and in nuclear-tipped cruise missiles.

Today's precision guidance systems have created opportunities to save money by using common systems across different programs. For example, GPS is nearly interchangeable among many different system types. Inertial navigation systems are now used in quantities that make it possible to save money by sharing systems from one program to the next, even if the precision requirement for one is higher than the other. This commonality brings dangers as well as opportunity, since a single factory can now be a bottleneck for multiple systems—another factor the Department must carefully manage as it moves forward.

RESPONSIVENESS OF THE ACQUISITION SYSTEM TO THE NEEDS OF THE DEPLOYED WARFIGHTER



THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS

FROM: ACTING UNDER SECRETARY OF DEFENSE (ACQUISITION, TECHNOLOGY AND LOGISTICS)

SUBJECT: Responsiveness of the Acquisition System to the High Priority Needs of the Deployed Warfighter

statistics on urgent need requests in support of the Combatant Commanders (COCOM). Specifically, for those urgent need requests that take more than 90 days from the point they are validated by the COCOM's Combined Joint Task Force to being received by the requesting organization, please provide me with the reasons for the delays so that we can work together to streamline the process and overcome such delays.

I look forward to working with you in these areas and I have asked Dr. Nancy Spruill, my Director for Acquisition Resources and Analysis, to work with your staffs to flesh out the details.

Michael W. Wynne
Acting

"Congress has given the Department tremendous authority and flexibility in this area, but too often we are reluctant to use that authority and flexibility..."

Source: Acting USD(AT&L)

More ubiquitous technology has also increased the options available to meet a given task, and increased the value of flexibility in meeting specific goals. Performance-based specifications for both JDAM and JASSM allow their contractors the freedom to employ the most cost effective means to meet those specifications. For JDAM, this meant a simple GPS guidance system and a very lean manufacturing line. For JASSM, it meant re-examining the airframe and finding a non-traditional subcontractor to build it cheaply.

The Department has provided program managers direction to manage their programs flexibly. This guidance includes the DoDD 5000.1 and specific recent guidance from USD(AT&L) , highlighted opposite.[29] Our comprehensive analysis of program management techniques employed by current program managers gives us confidence that they have the necessary tools, creativity, and flexibility to use this authority to deliver critical capabilities to the warfighter.

[29] USD(AT&L) memorandum, "Responsiveness of the Acquisition System to the High Priority Needs of the Deployed Warfighter," dated July 8, 2004.

TRANSFORMING DEPARTMENT DECISION-MAKING: CAPABILITIES-BASED PROCESSES

An integrated, capabilities-based approach to the acquisition process will drive changes in Department decision-making and corporate processes, in addition to challenging program managers to function in a capabilities context. By making decisions across functional and operational capability areas, program tradeoffs will be synchronized and prioritized with an increased understanding of relationships among programs by the broader acquisition community. These changes in acquisition oversight processes are at least as important as assuring that program managers' acquisition strategies and management techniques impart the functional capabilities context to individual programs.

PROGRESS TO DATE

As the Department moves its requirements and acquisition oversight processes toward a capabilities-based paradigm, changes in the current defense program oversight process are anticipated. As shown below, USD(AT&L) has three specific goals being worked by senior leadership teams. The goals provide complementary elements that

HOW AT&L GOALS[30] SYNCHRONIZE WITH SENIOR DEPARTMENT STRATEGY GUIDANCE AND THE 3170[31] CONSTRUCT

AT&L Goal One, Three, and Six deliverables provide complementary elements of end-to-end Department processes to implement JCIDS in Department acquisition oversight processes, system engineering, and industrial base assessments.

<table>
<tr><th></th><th>Goal One
Lead: Defense Procurement & Acquisition Policy</th><th>Goal Three
Lead: Defense Systems</th><th>Goal Six
Lead: Industrial Policy</th></tr>
<tr><td>Objectives</td><td>1. Bring Joint Capabilities perspective to acquisition
2. Increase accuracy and credibility of cost estimates
3. Shorten acquisition cycle time</td><td>1. Develop systems views of integrated architectures
2. Develop integrated plans and/or roadmaps
3. Establish broader mission context for DAB reviews
4. Foster interoperability, jointness, and coalition capabilities …</td><td>1. Capabilities-based approach to evaluate industrial base sufficiency
2. Organizational cross-feed mechanisms for IB assessments
3. Smart IB management by PMs
4. Help emerging defense suppliers bring value & innovation to DoD</td></tr>
<tr><td>Status</td><td>✓ DAES review in JFC context
✓ Prototype of Program Manager Functional Capability Conference (PMFCC) conducted June 2004
• Proof of concept PMFCC/CAR planned for Spring 2005</td><td>• Roadmap, investment strategies, and architectures in process for mission areas to support ACARs</td><td>• 5-part DIBCS study series underway in JFC context
• Until Department processes and organizations reflect JFC paradigm, companies will continue to sub-optimize on current customer-facing investment strategies</td></tr>
<tr><td>Deliverables</td><td><table><tr><th>JFC</th><th>PMFCC</th><th>CAR</th></tr><tr><td>C2/NCO</td><td>Mar 05</td><td>Apr 05</td></tr><tr><td>Force App</td><td>Apr 05</td><td>May 05</td></tr><tr><td>Protection</td><td>May 05</td><td>Jun 05</td></tr><tr><td>FocLog</td><td>Jun 05</td><td>Jul 05</td></tr><tr><td>BattlAwar</td><td>Jul 05</td><td>Aug 05</td></tr></table>In context of JFC and available roadmaps</td><td>✓ AMD roadmap and CAR DAB in May 2004
✓ Land Attack Weapons CAR DAB in May 2004
✓ JBMC2 CAR DAB in August 2004
• EW roadmap and CAR DAB planned for Nov 2004</td><td><table><tr><th>DIBCS Report</th><th>Publication Date</th></tr><tr><td>✓ Battlespace Awareness</td><td>January 2004</td></tr><tr><td>✓ Command & Control</td><td>June 2004</td></tr><tr><td>✓ Force Application</td><td>October 2004</td></tr><tr><td>Protection</td><td>December 2004</td></tr><tr><td>Focused Logistics</td><td>May 2005</td></tr></table>Other IB/Process enhancements:
• Industrial Base Investment Fund
• Shipbuilding Industrial Base Investment Fund</td></tr>
<tr><td>Periodicity</td><td>• Annual JFC CAR
• Other Department-level reviews as required
• Cost/schedule/milestone reviews at Service level to maximum extent possible</td><td>Continuous/ongoing</td><td>• Initial DIBCS series: Jan 04-May 05
• Less pressing critical technology industrial base assessments as required
• Complete update envisioned 2007-08</td></tr>
<tr><td></td><td colspan="3">← Crossfeeds →</td></tr>
</table>

Source: ODUSD(IP)

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[30] USD(AT&L) chartered six goals to be worked by his senior staff during the Airlie House Off-Site in June 2003. Goals One, Three, and Six relate to acquisition process and industrial base concerns.

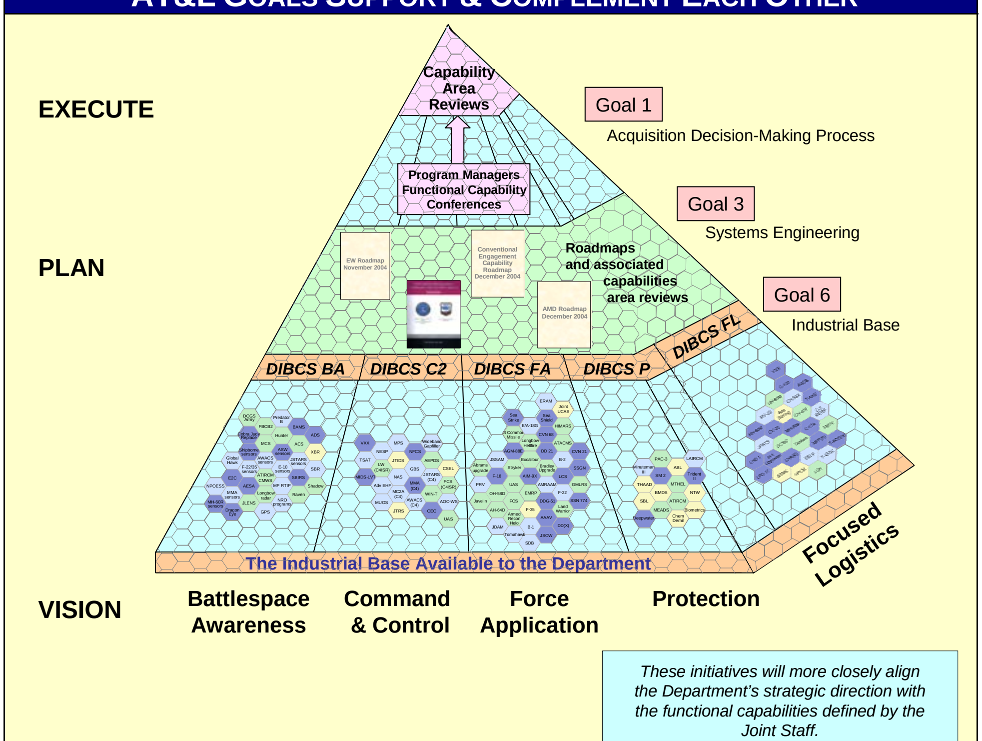
[31] Chairman of the Joint Chiefs of Staff Instruction 3170.01D, *Joint Capabilities Integration and Development System*, March 12, 2004.

align DoD's acquisition oversight processes, systems engineering, and industrial base assessments with the Joint Capabilities Integration and Development System (JCIDS) and the Secretary's imperative with regard to this capabilities context.

These three goal teams are working collaboratively to provide the foundation required for senior Department acquisition officials to make acquisition oversight decisions in a capabilities context. The Goal One team, chartered to bring a joint capabilities perspective to acquisition, is examining concepts that would scale current DAB reviews beyond single-program and mission capability area reviews to the larger joint functional concepts. The Goal Three team is providing the systems views, roadmaps, and integrated architectures in broader mission contexts that are building blocks for joint functional capability acquisition reviews. These initiatives in combination will foster interoperability, jointness, and coalition capabilities. Finally, the Goal Six team is applying this capabilities-based approach to industrial base assessments—and in so doing, is promulgating this capabilities-based vernacular from the warfighting community to the industrial base and its long-range investment and planning processes.

As shown below, if the industrial base is to effectively deliver the capabilities envisioned, all Department decision processes should be in the same functional capability vernacular. The proposed Program Manager Functional Capability Conference (PMFCC)/Capability Area Review (CAR) process, being examined by the Goal One team for implementation in 2005, is intended to accomplish this in concert with other Department initiatives and process changes.

AT&L GOALS SUPPORT & COMPLEMENT EACH OTHER



Source: ODUSD(IP)

The graphic opposite depicts how the DIBCS series has begun this synchronization by mapping warfighter capabilities to the supporting industrial base, enabling industry to establish better links to the warfighter. Armed with these studies, companies should be able to craft more effective business and investment strategies to serve DoD's warfighting goals, better communicate those strategies to the Department and other suppliers, and become important enablers of a networked, functional capability approach to modern warfighting. Companies early to market in this functional context will have substantial competitive advantages. Major defense companies already are reorganizing to respond. As companies improve their fluency in the functional-capabilities language, their ability to shape the DoD's imagination—and requirements—will improve. They will be better positioned to alert DoD program managers to technology and industrial capability connections among disparate defense programs, and better able to connect the dots on technologies with multiple applications than would an individual program manager.

> *"The functional-capability approach substantially broadens the opportunities available to industry well beyond individual programs or an individual military service. At the same time, the clear statement of this [capabilities] vision to industry should boost the flow of ideas and innovation into the department, creating a rich dialogue between industry and warfighter."*
>
> - *Suzanne D. Patrick, Deputy Under Secretary of Defense for Industrial Policy*
>   *Defense News—August 30, 2004*

The roadmaps and architectures that are part of Goal Three will inform precepts for the new CARs scaled to the joint functional concepts. They will, in aggregate, help determine the array of programs reviewed. These roadmaps to date have resulted in a series of targeted capability area reviews—Integrated Air and Missile Defense; Joint Battle Management Command and Control; and Land Attack Weapons.

THE NEW CAPABILITY AREA REVIEW PROCESS ENVISIONED

The PMFCC/CAR initiatives planned for 2005 will leverage the lessons learned from these targeted capability area reviews in order to put senior Department decisions in an even broader context, more closely aligned to the functional capabilities defined by the Joint Staff.

THE PMFCC/CAR

Process	Description
PMFCC	A preparatory conference to identify Department-level acquisition decisions by assessing programs in a capability context. During the intervening period between the PMFCC and CAR, issue working groups will validate and prioritize issues; explore options; and formulate recommendations.
CAR	A high level review body which makes the necessary decisions to improve program execution in a warfighter capabilities context. The CAR would assess synchronization, synergies, disconnects, and other issues across a large number of programs. DABs would remain program-specific reviews, delegated to the Services wherever practicable.

Source: ODUSD(IP)

A preparatory PMFCC would be held several weeks prior to the CAR to map selected acquisition programs to the Joint Staff's Joint Functional Concept (JFCs) and understand the interrelationships between the programs. During

the PMFCC, program managers would decompose their programs by the JFC functional capability areas and measure their program capabilities against the defined JFC attributes. In an exercise setting, the PMFCC will simultaneously evaluate multiple programs against their contribution to accomplish JFC capabilities, thereby identifying potential issues to be addressed at the CAR. The intervening time prior to the CAR will be used to validate and further investigate the issues identified at the PMFCC. These assessments will synchronize programs' ability to jointly enable the JFC. Associated decisions will optimize programmatic and budgetary resources for these programs. In turn, these required decisions would provide the basis for the Acquisition Decision Memorandum (ADM), prepared in advance of the CAR. It would then be validated during the CAR—and issued subsequently as programmatic and budgetary direction. DABs would remain program-specific reviews, delegated to the Services wherever practicable.

DEPARTMENT PROCESSES THAT INFORM PMFCC/CAR	
Process	**Description**
JOpsC	JOpsC is a unifying framework for developing subordinate concepts and capabilities. It lays out a strategic view of how the future Joint Force will operate and the overarching attributes with which to measure it.
JOCs	JOCs focus on the operational-level and describe how a Joint Force Commander will plan, prepare, deploy, employ, and sustain a joint force given a specific operation or campaign.
JICs	JICs are a further refinement of concepts focused on a specific class of operational missions or threads.
Source: ODUSD(IP)	

A multitude of existing Department processes, some of which are summarized in the chart above, will inform the envisioned PMFCC/CAR process and tie to the Department's strategic planning. The Joint Operations Concepts (JOpsC) provide an operational context for the CAR process based on the JFC description of functional capability areas and attributes. The four Joint Operating Concepts (JOCs) (i.e., Major Combat Operations, Stability Operations, Homeland Security, and Strategic Deterrence) articulate how the future force will operate within specific segments of the range of military operations. The Joint Integrating Concepts (JICs) (e.g., Joint Forcible Entry Operations, Undersea Superiority, Seabasing) describe critical tasks and associated capabilities needed to support specific missions—i.e., how a Joint Force Commander 10-20 years in the future will integrate capabilities to generate effects and achieve an objective. JICs have the narrowest focus of this family of concepts, and distill JOC and JFC-derived capabilities into fundamental tasks, conditions, and standards, enhancing the foundation required to conduct a CAR assessment.

The envisioned CARs would make decisions to optimize programs' collective ability to provide the functional capabilities required for 21st century warfare. In these high order reviews, the Department would assess synchronization, synergies, disconnects, and other issues across a large number of programs. The ensuing programmatic and budgetary decisions would be documented in an ADM for each functional CAR. As a body of decisions, these ADMs would represent annual, synchronized, and funded

capabilities oversight. They would also document oversight guidance responding to—and informing—Strategic Planning Guidance, Joint Programming Guidance, and Functional Capability Boards (FCBs).

"If programs were arrayed [across operational effects-based sectors], emerging defense suppliers would be able to ascertain opportunities that cut across individual programs and platforms… Conversely, senior DoD leaders would be better positioned to identify technology 'gaps' affecting both individual and multiple programs."

- "Transforming the Defense Industrial Base: A Roadmap," February 2003

As envisioned, these CARs would be held annually for each of the functional concepts that are directly tied to materiel solutions. In effect, the CARs would continue the process change accomplished by FCBs: programs initiated in functional contexts would be consistently monitored and re-synchronized to these contexts. We learned from our taxonomy work that programs are never static. Hence it is important to continually assure that all programs enabling given functional capabilities remain synchronized to these capability goals—and able to adapt to functional capability changes. An integrated, capabilities-based approach to program acquisition and associated oversight processes will not only improve Department decision-making, but also offers an enterprise-level view of a much broader expanse of the programs that collectively enable the desired warfighting capabilities. With this broader view, it should be possible to more effectively—and efficiently—inject innovation across the defense enterprise using the opportunity presented by the CAR process as an annual series of portals.

INDUSTRIAL BASE INVESTMENT FUND (IBIF)

The Industrial Base Investment Fund (IBIF) currently being conceptualized would create an innovation investment vehicle at the most senior level of the Department's acquisition process to iteratively inject real-time innovation in programs—from emerging and all available suppliers.

"The more innovative your offering, the higher you may have to go—right up through DoD headquarters, the military service secretariats, and even Congress."

- Mahlon Apgar, IV & John M. Keane, Harvard Business Review, September 2004

Initiatives such as the IBIF abound throughout industrial and govern-ment settings. Many industrial enterprises have vehicles such as Chairman Innovation Funds intended to promulgate high-value technologies developed within a given corporate entity across a broad array of business opportunities. The Central Intelligence Agency (CIA) develop-ed In-Q-Tel in February 1999 to discover, develop, deliver, and deploy actionable tech-nologies to enable selected CIA missions.

Congress has also encouraged funds to meet similar purposes, such as the Army's FY02 OnPoint non-profit venture fund with an initial $25 million of S&T funds. In FY03,

the Commercial Technology Transition Office of the Office of Naval Research initiated venture capital outreach efforts in response to Congress as well.

> ***The Industrial Base Investment Fund***
>
> *The Industrial Base Investment Fund (IBIF), upon initiation, will function as a "Chairman's Innovation Fund" managed by the Principal Deputy Under Secretary of Defense (AT&L) in his role as Joint Acquisition Executive. It will aim to fund producible multi-application innovation in programs of record.*
>
> *Investments will be nominated by the PM/PEO and acquisition communities and by corporate sources of innovation. A formal nomination process and associated application materials will be used to ensure consistency and a capabilities focus. It will be funded by Congressional appropriation. Fund guidelines to be generated later will provide asset allocation—guidance relative to investment levels among the joint functional capability areas. There also would be restrictions relative to sources and uses of investments, so that no one nominating entity and no one program could dominate the fund at any given time.*
>
> *All investment in any given fiscal year would be vetted by an Investment Advisory Board consisting of senior Department research, acquisition, and technology leaders. These investments would then be further vetted in the respective PMFCCs prior to being submitted with other programmatic direction in the advance ADM provided for the CARs. It is anticipated that IBIF funding would grow from $20-30 million ($4-6 million per JFC) in its first year of operation to $100 million at full maturity annually. The fund would not take equity positions in any companies.*

Indeed, the Department has funded similar ideas on its own, such as the Defense Venture Catalyst Initiative or DeVenCI. DeVenCI was formed at the direct request of the Secretary of Defense after 9/11. DeVenCI focuses almost exclusively on information technologies such as computer network defense, secure messaging, and visualization tools applicable to net-centric operations security and the Global War on Terrorism (GWOT). DeVenCI generally engages at an early stage of development and acts as a broker among stakeholders. Likewise, the Technology Support Working Group (TSWG) coordinates interagency and international research, development, and rapid prototyping resources on combating terrorism, to include counterterrorism, antiterrorism, intelligence support, and consequence management. TSWG operates under the management and oversight of the Assistant Secretary of Defense for Special Operations and Low-Intensity Conflict (SO/LIC) with funds drawn principally from DoD's Combating Terrorism Technology Support (CTTS) Program.

However, most programs and initiatives underway within the Department do not aim specifically at addressing *producible technology* suitable for *programs of record* in a vehicle that ensures *broadest possible dissemination of innovation across all warfighting applications.* The IBIF targets these areas:

- producible technologies;
- technologies easily injected into programs of record; and
- multiple, functional capability-based warfighting applications.

A taxonomy[32] developed as part of the concept development of the IBIF highlights coverage gaps of existing vehicles relative to the three key attributes of the IBIF. Indeed, the IBIF is likely to serve as an important complement to some of these existing vehicles. For example, it could provide a potential migration plan to shepherd innovation across the "valley of death" between technology development and acquisition programs for Advanced Concept Technology Demonstrations (ACTDs). The IBIF also could provide a migration plan to the most promising of DARPA technologies directly into programs of record. Joint Systems Integrating Command[33] may find the IBIF a valuable avenue to apply its concepts across the breadth of the defense enterprise.[34]
The capabilities context IBIF provides is also unique and can only be accomplished at the level of the Department's oversight of capability acquisition: the capability area reviews. The neglect of fully developed, near production-ready technology is particularly troubling to the Department. In many cases, the Department actively engages to fund technologies to this point[35]—and then all too often fails to leverage these investments to the benefit of the warfighter. As envisioned, the IBIF is the functional equivalent of a strong "red-zone offense" that pushes promising technologies over the goal line and fully leverages Department investments to benefit the warfighter.

> *"We're really good at driving the football down the field into the red-zone, but then we turn around and punt."*
> *- Red Team Member*

Description of the IBIF: Investment Sources

To meet this need, the IBIF would inject mature innovative technology into ongoing programs from the five sources shown opposite. Indeed, in order to assure early momentum, program managers' "injects" may be the primary investments of the IBIF in its initial years of operation. "Watch List" technologies could also provide early investment nominations.

FIVE INDUSTRIAL BASE INVESTMENT FUND SOURCES	
DoD	• Program Manager/Program Executive Officer nominations • "Watch List" technologies
Industry	• Innovative emerging firms • "Cutting room floor" innovative technologies from losing bids • Innovative technologies without available RFPs

Source: ODUSD(IP)

[32] See Appendix F for taxonomy of Department technology development in transition initiatives, including descriptions of programs/initiatives and definitions of taxonomy characteristics.
[33] Joint Systems Integrating Command (JSIC), formerly known as the Joint Battle Center (JBC), was stood up in December 1996 as a CJCS-controlled activity and later aligned under US Atlantic Command and then Joint Forces Command. Its principal function is to lead near-term joint force C4ISR through integrating and assessing new technology. It then provides objective recommendations for rapid insertion of solutions to support identified COCOM's needs for a joint task force (JTF).
[34] The IBIF, unlike the DoD Manufacturing Technology (ManTech) Program, focuses on inserting already-producible technology rather than on improving manufacturing processes.
[35] This is accomplished through a variety of DoD activities such as service laboratories and DARPA through the expenditure of science and technology funds and via a wide range of vehicles such as Small Business Innovation Research (SBIR) contracts.

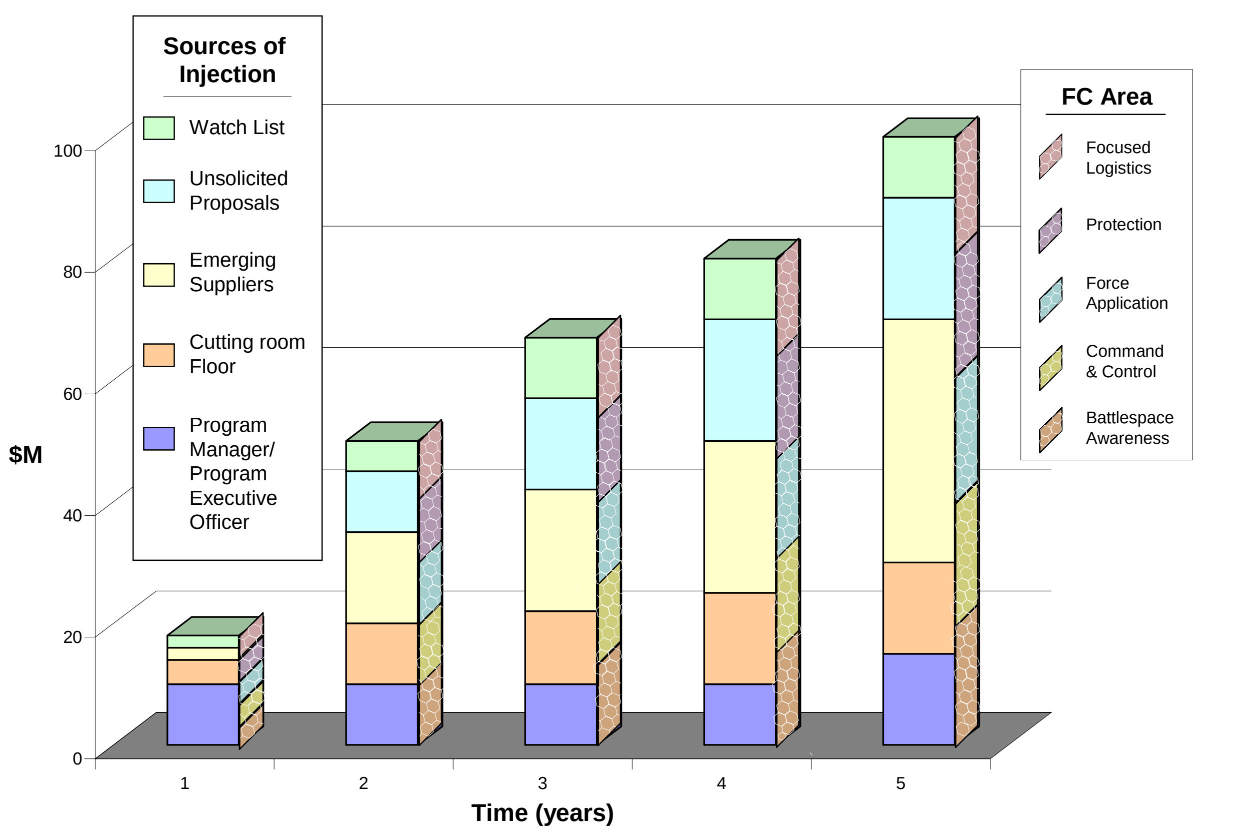
Over the longer term, the IBIF would function to provide innovative emerging firms robust on-ramps into programs of record. In our analysis, we have learned that while innovative S&T programs allow these companies to develop technologies, migration into programs is difficult. Innovative technologies from losing bids or those without available bidding opportunities would also be sources of IBIF investments.

The IBIF, over time, will likely provide innovative emerging firms—and the Department—an important vehicle not available in other vehicles or even through joint ventures with larger, more established defense firms. Corporate relationships with larger companies do not necessarily improve the Department's access to innovative companies. Sometimes larger companies can restrict visibility into smaller companies' innovation. First, based on their own strategic direction, prime contractors may not be motivated to advance innovation that may compete with proprietary approaches. Second, prime contractors might chose to be more predatory, actively seeking to "buy and bury" innovative technology rather than risk disrupting a lucrative and potentially captured market position—a point verified through our research and reengagement with smaller, innovative emerging defense suppliers. Third, emerging suppliers might "pick the wrong horse" by aligning with larger firms whose programs are imperfectly aligned with their technology. From the perspective of the emerging defense supplier, this could be catastrophic, and certainly does not leverage the full value of their technology to the firm or to the warfighter. From the Department's perspective, this largely ad hoc—and unsuccessful—market entry of emerging firms demonstrates a significant shortfall in Department processes and militates against broad awareness and application of innovative technology.

The Functioning of the Fund

The table below previews the IBIF's first five years of operation to illustrate its funding objectives and the anticipated uses of these Congressionally-appropriated funds.

THE INDUSTRIAL BASE INVESTMENT FUND: A NOTIONAL OPERATIONAL PREVIEW



Note: The side of each three-dimensional bar is divided into 5 equal segments representing notionally how the IBIF will be equally split among the 5 functional capability areas. There is no intended correlation to the face of the bar which delineates the sources of injection.

Source: ODUSD(IP)

In its first year of operation, the fund would likely not exceed $20-30 million and program manager/program executive officer-nominated investments would dominate the uses of funds. As the fund grows to full maturity, it would provide sturdy on-ramps for sources of innovation that are often waylaid by the Department's acquisition processes. These sources would include innovative firms without strong footholds in the defense enterprise, valuable technologies salvaged from losing bid proposals, and those technologies without contracting opportunities but viewed as synergistic with multiple programs of record.

INDUSTRIAL BASE INVESTMENT FUND APPLICATION

Instructions to applicants. Complete all fields as completely as possible. Submit separate forms for each product/technology. For items 3-6, choose appropriate selection from pull down menus. To make most effective use of this application, it is important to be very familiar with the Defense Industrial Capabilities Studies (DIBCS) which maps discrete enabling technologies to warfighting capabilities within broad functional architectures. Accurate technology/product positioning within this construct is critical for proper assessment, evaluation and screening. For items 4-6, refer to the appropriate DIBCS report appendix for definitions. Submissions are treated as applicant-proprietary by the Department of Defense. Submission assumes endorsement of Chief Technology Officer and Chief Executive Officer.

1 Organization Name/Location: *Include name of holding company/parent organization if applicable. City and state of headquarters and operating location responsible for technology/product (if different)*	**2 Organization Type:** *Public or private Company, non-profit institution, academic or federal lab, FFRDC, other.*
3 Organization Description: *Provide description of your firm/organization to include treatment of your size, experienec and capability, generally, and specifically as it pertains to your submission.*	**4 Functional Capability:** *Must be one of six Joint Staff/DIBCS defined functional architectures to which proposal applies (Battlespace Awareness, Command & Control, Force Application, Protection, Focused Logistics or Network Centric)*
5 Technology Area: *Specific technology area which is best fit for your technology/product. Technology area selections are defined by selection in block 4. Refer to Appendix B of the corresponding DIBCS report for listing.*	**6 Warfighting Capability:** *Specific warfighting capability enabled by technology/product. Capability selections are defined by selection in block 5. Refer to Appendix A of the corresponding DIBCS report for listing.*
7 Total Estimated Cost: *Include full treatment of NRE and recurring costs. Provide cost analogies as appropriate to reinforce estimates.*	**8 Estimated Time:** *Provide estimate of when first product can be delivered, if applicable, when interim operational capability will occur, and on what platforms.*
9 Competitive Assessment: *Describe differences between technology/product and most immediate competitor technologies/products and the state-of-the-art. Refer to company compendium of appropriate DIBCS report for list of competitors. Treatment should not be limited to these firms. Write in complete sentences. Limit response to 300 words.*	
10 Technology Maturity: *Describe the maturity of the technology. Use technology readiness level (TRL) if such an assessment has been done. If not, describe degree to which the technology/product has been demonstrated and is in use, either as part of a fielded system or as a commercial product. Treat risk. Write in complete sentences. Limit response to 300 words.*	
11 Producability Assessment: *Describe degree to which product/technology is being produced. Include current production volume, location of production facilities and surge capability/capacity with relative timing (i.e. how much time/investment to double production). Treat risk. Write in complete sentences. Limit response to 300 words.*	
12 Stakeholder Support/Validation: *Provide specific names, positions, organizations and contact information of stakeholders you've contacted with regard to this innovation, the degree and type of support received. Write in complete sentences. Limit response to 300 words.*	
13 Chief Technology Officer: *Enter name and contact information to include address, e-mail, phone and fax numbers. Unless otherwise indicated, it is assumed the CTO is the primary point of contact.*	**14 Chief Executive Officer:** *Include name and contact information to include address, e-mail, phone and fax.*

Source: ODUSD(IP)

These investments would be implemented and monitored through the PMFCC/CAR process. In the first year, investments would be provided to respective program managers at funding levels agreed to in the PMFCC and the CAR. In the following PMFCC/CAR cycle, program managers could petition for additional funding. By the third year, if relevant, the program manager would be expected to fund these items within the program, including operational test and evaluation and life cycle requirements.

As mentioned earlier, candidate "injects" must be significantly mature and production-ready—generally the equivalent of a Technology Readiness Level (TRL) six or higher.[36] Firms would submit candidate nominations to the DIBCS lead via a comprehensive application form,[37] which is shown above. This application would be reviewed with appropriate DoD subject matter experts. An Investment Advisory Board (IAB) then would forward the most promising candidates to the PMFCC/CAR leads for funding consideration within the annual CAR cycle. This IAB would include Department experts such as DDR&E, DARPA, and other USD(AT&L) staff, as shown opposite.

The IBIF Director would closely monitor technology "injects" and measure success

NOTIONAL COMPOSITION OF THE INDUSTRIAL BASE INVESTMENT FUND (IBIF) INVESTMENT ADVISORY BOARD

Director, IBIF
Director, Defense Research & Engineering
Director, Defense Advanced Research Projects Agency
Capability Area Leads:

- *Battlespace Awareness*
- *Command & Control*
- *Force Application*
- *Protection*
- *Force Logistics*

Chairman: Principal Deputy Under Secretary of Defense (AT&L).

[36] Under special circumstance, a technology might have to be handled as if it had a lower TRL in order to adapt it to a specific military application. See Appendix H for brief description of technology readiness levels.

[37] See Appendix I for proposed template of application form. Proposals received as a result of this report and others in the DIBCS series will be used to further refine the IBIF concept—and may provide it investment backlog.

through the next year's CAR process. In this way, the IBIF will be similar to a "Chairman's Fund" in private industry. As suggested earlier, it may also be an effective avenue through which to address DIBCS "Watch List" concerns.

We have "Red-Teamed" the IBIF concept with several emerging firms and legacy defense suppliers, and it has been received with great enthusiasm. Emerging defense suppliers view it as a viable avenue to market, providing them a champion for innovation accessing Department resources and decision-making capabilities at the most senior levels. Prime contractors see it as a vehicle to get a more capable product to the warfighter and be more responsive to the customer and national security needs.

For the acquisition community, it provides a funding vehicle of last resort for innovation that otherwise would not be funded. The Department will greatly accelerate real time innovation of warfighter capabilities if this concept is institutionalized and proves successful.

Potential Candidate IBIF Investments

Our continuing visits to emerging defense suppliers have reinforced our convictions as to the utility of the IBIF. Indeed, these suppliers have provided us numerous examples of potential candidates. For example, iRobot[38] has secured a substantial role on the FCS program and provides the new Packbot™ to troops in Afghanistan and Iraq, primarily for improvised explosive device (IED) detection and disposition. However, the company is seeking sponsorship for its unmanned ground vehicle, developed in partnership with John Deere. The technology is mature, does not correspond to existing program requirements, and yet could offer the Air Force and Navy a ground handling system for munitions transport, and meet Army non-combat, logistics transportation needs. This is a case where the fund could significantly accelerate robotic technology integration into the Services.

In another company example, Aerovironment has long been known for breakthrough products and radical innovation. The company recently demonstrated technologies for a UAV capable of loitering at extreme altitudes for weeks at a time—qualifying for a TRL of six or higher. Such a capability has promise across a wide range of applications, from ultra-wideband communications relay to very long duration intelligence, surveillance, and reconnaissance missions. Indeed, the capability has the potential to redefine

> *"From industrial base assessments done as part of the DIBCS series to date, we know the importance of small companies in supplying critical warfighting technologies—and the Department's imperfect record in accessing them. Of over 500 U.S. companies assessed in our previous two DIBCS reports as having critical technologies relevant to BA/BWA warfighting capabilities, nearly 40 percent of these companies have 100 employees or less. Therefore, we believe it is critically important that these small companies with the most innovative technologies have better access to the Department's weapon system programs."*
>
> - *Suzanne D. Patrick,*
>   *AIA Conference, September 23, 2004*

[38] Citation of specific companies in this report does not imply future business opportunities with or endorsement by DoD.

what is meant by persistence. The company has received interest from no less than a dozen military customers. However, no single customer is able or willing to support a program that would so radically surpass current operational capability and change doctrine—despite acknowledging its profound merits. This would be a very important unmanned technology applicable to numerous functional concepts (BA, C2, and possibly FA and Protection). This technology would seem to be an ideal candidate for IBIF funding spread across programs in several functional concepts, given the absence of stated requirements, the substantial estimated funding, and its multiple applications.

> *"To have a champion for innovation, empowered to pull new technology directly into programs…That would be awesome."*
>
> - *Vanu Bose, CEO of Vanu, Inc, developer of the Vanu Software Radio ™ technology*

Vanu, Inc., with leading edge capabilities in software radio development, is a contractor for the Joint Tactical Radio System (JTRS) program. Its innovative capability to meet high performance radio communication requirements in laptop configurations would provide the warfighter extremely portable, flexible, and cost effective software radio solutions. The Department did not envision these capabilities, nor were they available, when it crafted the requirements and acquisition strategies for JTRS and associated military programs. Therefore, this application could disrupt the JTRS acquisition strategy and those programs that depend on JTRS. The PMFCC/CAR could assess the utility of this technology and provide funding through the IBIF.

As these examples demonstrate, in many ways the IBIF would "challenge" programs of record as envisioned by the Defense Acquisition Challenge (DAC) program mandated by Congress in the FY03 National Defense Authorization Act. However, the IBIF would be more effective because the IBIF would be linked to Department oversight and budgeting processes and therefore provide more direct links to program funding.

We also believe that the IBIF could leverage investment in innovative suppliers from financial and corporate investors. Better yet, such investors may attempt to anticipate IBIF investments in order to invest first for higher returns. The IBIF could also provide funding streams for smaller companies, now often only available through merger and acquisition transactions. In this way, the IBIF would reinforce the Department's aim to foster myriad sources of innovation for high priority technologies in smaller scale companies.

The Department finds itself at an important juncture with a rare opportunity to make a non-linear improvement to meet warfighter needs. By leveraging broader acquisition process and oversight changes within the functional capabilities construct, the Department is positioned to increase the efficiency, speed, and effectiveness with which it inserts technology from all defense firms into programs.

PART IV

POLICY REMEDIES FOR FORCE APPLICATION INDUSTRIAL BASE ISSUES

The Department has a rich history of programmatic lessons learned that it can apply to support the development, fielding, and continued improvement of *BA/BWA* warfighting capabilities. Our initial assessment identified two priority critical technologies that we placed on a "Watch List" and six for which we recommend remedies. As we examine the remaining critical technologies and associated industrial base, we will undoubtedly uncover additional issues. Appropriate remedies for those issues will be considered at that time.

As discussed earlier in this report, we assessed that the industrial base for 21 of the 32 priority critical FA technologies was sufficient. While some of the technologies are still in development, we are confident that the industrial base for them will prove adequate because of the number of U.S. contractors and research institutions involved and the overall lead they possess.

THE FA "WATCH LIST"

We identified two unique technologies for key warfighting capabilities that require special Department consideration, as shown in the chart below.

FORCE APPLICATION INDUSTRIAL BASE "WATCH LIST"

Technologies	Industrial Base Sufficiency				Policy Levers		
	Technology Readiness Level (TRL)	Domestic Sources	Foreign Sources		Fund Innovation	Optimize PM Structure & Acq Strategy	External Corrective Measures
Million-Rounds-Per-Minute Gun ("Metal Storm")	TRL 9	0	1		DARPA consider funding development and test	Assess sponsorship in Army and Navy	Potential disruptive technology. Assess as potential IBIF Initiative. Monitor proliferation.
Electro-Hydraulic Cavitation Device	TRL 6	1	0		Highlight as potential S&T investment	Assess sponsorship in Army and Navy	Potential disruptive technology. Assess as potential IBIF Initiative. Monitor proliferation.

Source: IP and Booz Allen Hamilton

The recommendations use the portals and levers construct developed in the *DIBCS BA* study, as recapped in Appendix D of this study.

Million-Rounds-Per-Minute Gun ("Metal Storm"). "Metal Storm" could be an important technology for future warfighters. This technology exists today, and has been demonstrated in several configurations with varying ammunition loads. "Metal Storm" offers the warfighter an offensive and defensive capability that can be adapted for air,

land, or sea, replacing weapons such as Phalanx or the airborne weapons used on AC-130s.

There are no U.S. suppliers for this breakthrough technology. Even though the Australian supplier has a tie to the United States through DARPA, there are no plans for DoD programs to use “Metal Storm.” Technology proliferation risks exist. Further DARPA work on this program could focus Department attention and prevent proliferation by putting into place appropriate technology controls. The IBIF could provide this technology to the FCS program, the Navy’s PEO for surface warfare, and the Marine Corps Warfighting Laboratory.

Electro-Hydraulic Cavitation (EHC) Device. EHC technology could make possible a hard-kill, anti-torpedo defense that allows extended shoot-look-shoot engagements. The threat driving such hard-kill defenses is the no-warning threat posed by bottom-moored torpedo mines. EHC technology enables a capability that does not currently exist.

Tetra Corporation appears to be the sole provider of this technology. This research is still in the early stages but clearly represents a breakthrough. Using Small Business Innovation Research funds, Tetra developed this technology in a proof-of-principle system. To ensure further development and sufficient operationally-relevant testing, the Department should consider developing additional domestic sources to achieve the level of maturity necessary for sea trials. The FCB that oversees the Joint Undersea Superiority JIC could sponsor demonstrations to nurture the technology. The IBIF would also be a good avenue to transition this potentially disruptive technology to programs. The Department should also monitor the technology via the export control process to prevent proliferation to potential adversaries.

ISSUES IN THE FA INDUSTRIAL BASE

The six technologies shown in the following table lack industrial base sufficiency. Given that these technologies are not yet in production, there is ample opportunity to make appropriate investments through structured competitions that can strengthen the industrial base—ensuring adequate availability of the technology to the warfighter.

FORCE APPLICATION INDUSTRIAL BASE ISSUES							
Technologies	**Industrial Base Sufficiency**				**Policy Levers**		
	Technology Readiness Level (TRL)	**Domestic Sources**	**Foreign Sources**		**Fund Innovation**	**Optimize PM Structure & Acq Strategy**	**External Corrective Measures**
Pulsed Plasma Thruster	TRL 5	2[39]	0		Fund innovation as cooperative agreement with NASA.	Provide competitive opportunities for this technology in weapon system design.	Deny teaming agreements and transactions that limit innovation. Consider for Militarily-Critical Technology List.
Hypersonic Weapon Propulsion System	TRL 7	1	1		Invest in demonstrating technology and establish producers.	Provide competitive opportunities for this technology in weapon system design.	Deny teaming agreements that limit innovation. Closely monitor U.S. industrial base through HSR and CIFUS processes.
Small Caliber Projectile Control Surfaces	TRL 4	0[39]	0		Invest in R&D to demonstrate technology and gain sponsorship.	Structure competitions to foster the entry of additional sources.	Deny teaming agreements that limit innovation. Closely monitor U.S. industrial base through HSR and CIFUS processes.
GPS-Guided Small Diameter Bomb (SDB)	TRL 8	1	0		Fund innovation by competitively establishing a second source.	Structure competitions to allow entry point for second source.	Use HSR and CIFUS processes to control second tier supplier consolidation.
Chemical Oxygen-Iodine Laser (COIL) (High/Low Power)	TRL 7	2 High 3[39] Low	0 High 3[39] Low		Fund demonstration of COIL for other warfighting applications.	Provide competitive opportunities for this technology in weapon system design.	Deny teaming that limits innovation; maintain present number of sources at minimum.
Self-Propagating High-Temperature Synthesis Device	TRL 6	1[39]	0[39]		Invest in R&D to demonstrate technology to gain sponsorship.	N/A	Stage competitions to add sources. Consider for Militarily-Critical Technology List.
Source: Booz Allen Hamilton and ODUSD (IP)							

Pulsed Plasma Thruster. Pulsed plasma power thrusters provide an efficient and effective solution for spacecraft propulsion. By introducing a low mass propulsion solution, this technology enables increasingly complex space missions, orbital transfers and attitude adjustments, and precision space asset pointing. This is an enabling technology offering a capability not available today.

Only two domestic suppliers produce pulsed plasma thruster technology: Aerojet and Science Research Laboratory. Applying the proper simultaneous funding of innovation through the Department and NASA would allow the United States to create a joint civil

[39] Additional R&D underway at other sources, not yet in production.

and military industry which would broaden the market and ensures a competitive and innovative industrial base. The Department should monitor the development of this industrial base and control export of this technology.

Hypersonic Weapon Propulsion System. Solid rocket hypersonic weapon propulsion offers the warfighter substantial reductions in shooter-to-target engagement times. This technology minimizes countermeasure response times and pays big dividends when engaging time-sensitive, perishable targets such as mobile Scud missiles.

The Department faces an insufficient industrial base—one domestic and one German source. At present, the United States is even with the rest of the world, with no discernable technology lead. To secure leadership, the Department should provide additional R&D funding to demonstrate the technology and to create competitive opportunities for weapon system designs. Additionally, the Department should closely monitor teaming arrangements and corporate acquisitions to ensure a competitive landscape prevails and appropriate export controls are maintained.

Small Caliber Projectile Control Surfaces. This breakthrough technology offers the warfighter a capability to perform mid-course and terminal guidance to defeat hidden or moving land targets. This technology does not replace existing weapons but improves their capability.

The United States leads in this technology. Because of the lack of maturity of this technology, no domestic suppliers are producing this technology. Both Lockheed Martin (with the University of Florida) and Auburn University are actively researching the technology. We found no foreign suppliers for small caliber projectile control surfaces, but found several foreign manufacturers of medium and large caliber projectile control surfaces. Their technology could potentially be improved and applied to small-caliber munitions. The Department should invest in R&D and sponsor competitive development programs to apply the technology and foster entry of additional sources. This is another technology where a single large corporation could take control of the technology if the Department does not actively manage the development of the industrial base.

GPS-Guided Small Diameter Bomb (SDB). GPS-Guided SDBs will be a force multiplier, providing greater capability to destroy or degrade targets in an urban environment with limited collateral damage. Based on a recent competitive downselect decision, the Department now has only one supplier—Boeing. If the United States is to maintain its lead in the precision strike *BA/BWA* capability SDB provides, it needs additional suppliers. The Department should reconsider the SDB acquisition strategy and provide funding to competitively establish a second source or alternative solution. If appropriate, the Department should create additional opportunities to allow for the entry and maintenance of this and other sources. The Department should monitor the industrial landscape to ensure that a single prime contractor does not acquire or enter into exclusive teaming arrangements with the second tier sources of guidance systems, warheads, and control surfaces.

Chemical Oxygen-Iodine Laser (COIL). COIL technology will provide the warfighter with a directed energy weapon capable of destroying or degrading land and air targets, with minimal collateral damage. Such weapons are envisioned primarily for missile defense, but are being considered for other warfighting capabilities. The United States has only two developers of such high-powered lasers: Northrop Grumman and Boeing. Other companies and research institutions continue to do advanced research in high-powered lasers, some for commercial and industrial uses. The Department should strengthen this industrial base by providing opportunities for this technology to compete in other weapon system designs. This would allow the technology to mature faster and expand the market, providing an incentive for other sources to enter. The Department will have to carefully screen teaming arrangements to ensure innovation is not suppressed as a result of acquisitions.

Self-Propagating High-Temperature Synthesis (SHS) Device. This dual-effect (high-energy and radio frequency effects) technology will enable capabilities to destroy/degrade and deny/disrupt land targets, replacing napalm or fragment weapons while also providing an electronic warfare capability. The United States has no discernible leadership in SHS technology. Only one U.S. company is actively seeking funding. Given the low maturity level of this technology and the innovation of nano-particle suppliers, new suppliers could enter the market if the Department sponsors competitions to "weaponize" this technology. At present, weaponized SHS work is confined to the United States, but Europe, Japan, Singapore, and South Korea could challenge the United States in the near future. Export control of the weaponized technology is crucial.

THE ROLE OF ODUSD(IP) AND THE INDUSTRIAL BASE

In addition to these specific remedies, the DIBCS assessments to date have reinforced our conviction that the methodology is sound and the ODUSD(IP)'s role as the clearinghouse for industrial base deficiencies is important. ODUSD(IP) should continue this role and continue to assess FA industrial base sufficiency using the capabilities framework, databases, and policy tools developed in this study. ODUSD(IP) also should use this framework for industrial base capabilities assessments for Protection and Focused Logistics.

For several reasons, ODUSD(IP) is uniquely positioned and qualified to serve in this clearinghouse capacity. ODUSD(IP) maintains insight into Service, Defense Agency, other Department, and interagency industrial base activities as part of its day-to-day responsibilities. ODUSD(IP) compiles and publishes the Congressionally-mandated *Annual Industrial Capabilities Report to Congress*.[40] Finally, ODUSD(IP) represents the Department on industrial base issues considered in the interagency process.

The Department should continue to closely monitor FA *BA/BWA* warfighting capabilities, their enabling technologies, and the associated industrial base. The Department should

[40] See Section 2504 of Title 10, United States Code.

be prepared to deploy appropriate actions for “Watch List” technologies through the remedies indicated. The Department also should remedy identified technology deficiencies. Effective use of policy levers can facilitate innovation and competition within the industrial base. The establishment and effective use of the IBIF can inject innovative technologies into programs of record.

The DIBCS methodology, the use of the IBIF, and the associated portals and levers will, in combination, provide the necessary tools to strengthen the industrial base available to the Department. Applying these tools with diligence will greatly increase confidence that critical technologies and associated industrial base capabilities are available when needed to maintain U.S. warfighting superiority over any potential adversary.

AFTERWORD

With the publication of *DIBCS FA*, we are now beyond the half way point in our assessment of priority critical technologies and industrial base capabilities for the five Joint Staff functional concepts where materiel solutions are most important. We remain convinced that this work truly represents a "long forward pass" that will ensure that the American way of war remains way ahead of potential adversaries well into the 21st century.

But what about the here and now? Admittedly, the full implementation of the remedies identified in the DIBCS series, as well as the institutionalization of associated process changes, will happen over time. We plan to begin a large scale communications and socialization strategy to institutionalize DIBCS concepts and processes upon completion of the series in mid-2005. However, as the table below highlights, many of the levers available to implement these remedies are within the purview of ODUSD(IP). We are employing these levers real time as industrial base issues surface.

ODUSD(IP)'s charter to review program acquisition strategies to ensure industrial base health provides us opportunities to influence programs in the following ways: to stage competitions to add sources; to restructure management approaches; and to block anti-competitive teaming arrangements. In ODUSD(IP)'s deliberations in the interagency settings that relate to merger and acquisition decisions, we already utilize Hart-Scott Rodino and Exon-Florio remedies to maintain sufficient numbers of competitive sources, technology leadership, and security of supply (the latter, in cases of foreign acquisitions of U.S. firms). The IBIF would provide a further lever to fund producible multi-application innovation in programs of record. If companies use the application process associated with the IBIF to propose such innovation, they will—in effect—be mapping their most innovative capabilities to the Department's priorities and be participating in the further validation of this concept.

REMEDIES

DoD		Interagency	
Measure	**Purpose**	**Measure**	**Purpose**
Fund S&T	Fund government and industry technology development to incorporate critical technologies in defense systems	Hart-Scott-Rodino Remedies	Maintain sufficient number of competitive sources
Stage competitions to add sources	Induce innovation. Major risk reduction for too few/failing source(s) or lack of performance	Exon-Florio Remedies	Maintain technology leadership and security of supply but allow foreign direct investment
Restructure Management Approach	Eliminate excessive self-dealing or narrow focus on specific issues or applications	Balanced Export Controls	Keep military technology from adversaries but allow competition in global markets
Block Teaming Agreement	Discourage fusion of innovation into single source; prevent cartel-like behavior	Foreign Cooperative Agreements	Help develop and access foreign sources where appropriate
Industrial Base Investment Fund	Fund producible multi-application innovation in programs of record		

Sources: ODUSD(IP)

Longer term, ODUSD(IP) will work with other DoD organizations to encourage the employment of levers outside of ODUSD(IP) purview. The Services and the Director, Defense Research and Engineering within the OUSD(AT&L) have responsibility for levers such as funding S&T and Foreign Cooperative Test Agreements. Within the Department, balanced export controls are the responsibility of the Under Secretary of Defense (Policy).

Well beyond the U.S. industrial base, the methodologies and processes being developed in the DIBCS series are taking root. The United Kingdom is exploring using the DIBCS concepts for its own industrial base assessments relating to future warfighting capabilities. Australia is considering using the DIBCS process in its own warfighting capabilities assessments to inform Australian industrial base considerations. Austrian defense officials have arrayed their defense companies into the five functional concepts and are briefing their capabilities to the Department using the IBIF application materials.

We encourage readers to continue to provide us feedback as these studies progress. Most importantly, we hope that this series will encourage companies to enter the defense enterprise.

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ACRONYMS

ABL	Airborne Laser
ACS	Advanced Deployable System
ACTD	Advanced Concept Technology Demonstration
AEHF	Advanced Extremely High Frequency
AH-64	Apache Helicopter
AMD	Air & Missile Defense
AMF JTRS	Airborne, Maritime/Fixed Station Joint Tactical Radio System
AOC-WS	Air Operations Center – Weapon System
APS	Advanced Polar System
ARA	Acquisition Resources & Analysis
ATIRCM/CMWS	Advanced Threat Infrared Countermeasure/Common Missile Warning System
AWACS	Airborne Warning and Control System
B-2	Multi-role bomber aircraft
BA	Battlespace Awareness
BA/BWA	Be Ahead and Be Way Ahead
BAH	Booz Allen Hamilton, Inc.
BAMS	Broad Area Maritime Surveillance
BMC2	Battle Management Command and Control System
BMDS	Ballistic Missile Defense Program
C2	Command and Control
C-5 RERP	C-5 Reliability Enhancement and Re-Engineering Program
C-17	Globemaster III Advanced Cargo Aircraft
C-130	Hercules Cargo Aircraft
C-141	Starflifter Cargo Aircraft
C3I	Command, Control, Communications, and Intelligence
CAIV	Cost as an Independent Variable
CAR	Capability Area Review
CAVE	Cave Automatic Virtual Environment
CDM	Capability Decision Memorandum
CEO	Chief Executive Officer
CFIUS	Committee on Foreign Investment in the United States
CH-47	Cargo Helicopter
Chem DeMil	Chemical Demilitarization Program
CJCSI	Chairman of the Joint Chief of Staff's Instruction
COIL	Chemical Oxygen Iodine Laser
COTS	Commercial Off-the-Shelf
CVN	Nuclear-powered Aircraft Carrier
CVN 21	21st Century Aircraft Carrier
DAB	Defense Acquisition Board
DAES	Defense Acquisition Executive Summary
DARPA	Defense Advanced Research Projects Agency
DCGS	Distributed Common Ground System
DDG	Guided Missile Destroyer

DDX	Future Destroyer
DIBCS	Defense Industrial Base Capability Study
DJC2	Deployable Joint Command and Control
DoD	Department of Defense
DoJ	Department of Justice
DDR&E	Director, Defense Research and Engineering
DPAP	Defense Procurement and Acquisition Policy
DS	Defense Systems
DSCS/GBS	Defense Satellite Communications System/Global Broadcast Service
DUSD(IP)	Deputy Under Secretary of Defense (Industrial Policy)
E-2C	Advanced Hawkeye Aircraft
E-3	Sentry Airborne Warning and Control System (AWACS) Aircraft
E-10A	Multi-Sensor Command and Control Aircraft
EHC	Electro-Hydraulic Cavitation
EMP	Electromagnetic Pulse
EP-3	Aries (Airborne Reconnaissance Integrated Electronic System)
EW	Electronic Warfare
FA	Force Application
F/A-18	Hornet Fighter/Attack Aircraft
F/A-22	Raptor Fighter/Attack Aircraft
FAFC	Force Application Functional Capability
F-35	Joint Strike Fighter
FBCB2	Force XXI Battle Command Battalion/Brigade and Below
FCB	Functional Capability Board
FCS	Future Combat System
FL	Focused Logistics
FMS	Foreign Military Sales
FMTV	Family of Medium Tactical Vehicles
FTC	Federal Trade Commission
GCSS	Global Combat Support System
GBS	Global Broadcast System
GCCS-J	Joint Global Command & Control Systems
GMLRS	Guided Multiple Launch Rocket System
GMTI	Ground Moving Target Indication
GPS	Global Positioning System
GWOT	Global War on Terrorism
HALE	High Altitude Long Endurance (UAV)
H-S-R	Hart-Scott-Rodino
HEDM	High Energy Density Material
HIMARS	High Mobility Artillery Rocket System
HPM	Hybrid Power Management
IB	Industrial Base
ID	Identification
IDA	Institute for Defense Analyses
IED	Improvised Explosive Device
IFDL	Intraflight Data Link
IFF	Identification Friend or Foe

IP	Industrial Policy
JASSM	Joint Air-to-Surface Standoff Missile
JBMC2	Joint Battle Management Command and Control
JC2FC	Joint Command and Control Functional Concept
JCIDS	Joint Capabilities and Integration Development System
JDAM	Joint Direct Attack Munition
JFAFC	Joint Force Application Functional Concept
JFC	Joint Functional Concept
JIC	Joint Integrating Concept (subordinate to JOC)
JOC	Joint Operating Concepts (subordinate to JOpsC)
JOpsC	Joint Operations Concepts
JPALS	Joint Precision Approach and Landing System
JSF	Joint Strike Fighter
JSOW	Joint Standoff Weapon
JSTARS	Joint Surveillance Target Attack Radar System
JTRS	Joint Tactical Radio System
LRIP	Low Rate Initial Production
LW	Land Warrior
MAV	Micro Air Vehicle
MC2A	Multi-sensor Command and Control Aircraft
MCS	Maneuver Control System
MEMS	Micro-electro-mechanical System
MIDS-LVT	Multi-functional Information Distribution System-Low Volume Terminal
MH-60R	Multi-Mission Helicopter Upgrade
MM III	Minuteman III
MMA	Multi-mission Maritime Aircraft
MPF	Maritime Prepositioning Force
MPS	Mission Planning System
MUOS	Mobile User Objective System
NCO	Net Centric Operations
NESP	Navy EHF Satellite Communication Program
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NTW	Navy Theater Wide
ODUSD(IP)	Office of the Deputy Under Secretary of Defense (Industrial Policy)
OSD	Office of the Secretary of Defense
PAC-3	Patriot Advanced Capability-Phase 3
PMFCC	Program Manager Functional Capability Conference
PPT	Pulsed Plasma Thruster
QRSP	Quick Reaction Special Projects Program
R&D	Research and Development
RF	Radio Frequency
S&T	Science and Technology
SAG	Senior Advisory Group
SATCOM	Satellite Communication
SBIR	Small Business Innovation Research program
SBIRS-High	Space-Based Infrared System – High
SDB	Small Diameter Bomb

SDD	System Development and Demonstration
SHS	Self-Propagating High-Temperature Synthesis
SM 6	Standard Surface-to-Air Missile 6
SSGN	Nuclear-Powered Cruise Missile Submarine
T-AKE	Lewis and Clark Class of Auxiliary Dry Cargo Ships
TBMCS	Theater Battle Management Core Systems
THAAD	Theater High Altitude Area Defense
TSAT	Transformational Satellite Communication System
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
UH-60M	Blackhawk Utility Helicopter Upgrade
U.S.	United States
USAF	United States Air Force
USCENTCOM	United States Central Command
USD(AT&L)	Under Secretary of Defense (Acquisition, Technology, and Logistics)
USN	United States Navy
USSPACECOM	United States Space Command
UV	Unmanned Vehicle
V-22	Osprey Joint Advanced Vertical Lift Aircraft
WGS	Wideband Gapfiller: Wideband Communications Satellite System (fills the gap between DSCS/GBS and Advanced Wideband System)
WIN-T	Warfighter Information Network-Tactical

APPENDIX A

DIBCS FORCE APPLICATION CAPABILITY FRAMEWORK

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Maneuver to Engage

The self-deploy capability to move to the domain of the engagement, be it air, land, sea, space or cyber. Each of these domains were assessed individually and the results reported below.

Air Neutral
• None

Air Equal
• Perform short-range, subsonic, terrain-adhering, small aircraft transit (for self deployment and/or flight to/from operating area)
• Perform short-range, subsonic, high-altitude, large aircraft transit (for self deployment and/or flight to/from operating area)
• Perform short-range, subsonic, high-altitude, small aircraft transit (for self deployment and/or flight to/from operating area)
• Perform short-range, supersonic, terrain-adhering, large aircraft transit (for self deployment and/or flight to/from operating area)
• Perform short-range, supersonic, terrain-adhering, small aircraft transit (for self deployment and/or flight to/from operating area)
• Perform short-range, supersonic, high-altitude, large aircraft transit (for self deployment and/or flight to/from operating area)
• Perform short-range, supersonic, high-altitude, small aircraft transit (for self deployment and/or flight to/from operating area)
• Perform long-range, subsonic, high-altitude, large aircraft transit (for self deployment and/or flight to/from operating area)
• Perform long-range, subsonic, high-altitude, small aircraft transit (for self deployment and/or flight to/from operating area)
• Extend the range of fixed-wing aircraft via ability to accept aerial refueling enroute
• Extend the range of rotary-wing aircraft via ability to accept aerial refueling enroute
• Perform short-range, low-altitude, low-endurance UAV transit (for self deployment and/or flight to/from operating area)

Maneuver to Engage – Cont.

Air Be Ahead
• Perform long-range, subsonic, terrain-adhering, large aircraft transit (for self deployment and/or flight to/from operating area)
• Perform long-range, subsonic, terrain-adhering, small aircraft transit (for self deployment and/or flight to/from operating area)
• Perform long-range, supersonic, terrain-adhering, large aircraft transit (for self deployment and/or flight to/from operating area)
• Perform long-range, supersonic, terrain-adhering, small aircraft transit (for self deployment and/or flight to/from operating area)
• Perform long-range, supersonic, high-altitude, large aircraft transit (for self deployment and/or flight to/from operating area)
• Perform long-range, supersonic, high-altitude, small aircraft transit (for self deployment and/or flight to/from operating area)
• Perform medium-range, medium-altitude, medium-endurance UAV transit (for self deployment and/or flight to/from operating area)

Air Be Way Ahead
• Perform long-range, hypersonic, high-altitude, large aircraft transit (for self deployment and/or flight to/from operating area)
• Perform long-range, hypersonic, high-altitude, small aircraft transit (for self deployment and/or flight to/from operating area)
• Perform long-range, hypersonic, transatmospheric, large aircraft transit (for self deployment and/or flight to/from operating area)
• Perform long-range, hypersonic, transatmospheric, small aircraft transit (for self deployment and/or flight to/from operating area)
• Perform global-range, hypersonic, high-altitude, large aircraft transit (for self deployment and/or flight to/from operating area)
• Perform global-range, hypersonic, high-altitude, small aircraft transit (for self deployment and/or flight to/from operating area)
• Perform global-range, hypersonic, transatmospheric, large aircraft transit (for self deployment and/or flight to/from operating area)
• Perform global-range, hypersonic, transatmospheric, small aircraft transit (for self deployment and/or flight to/from operating area)
• Perform long-range, high-altitude, long-endurance UAV transit (for self deployment and/or flight to/from operating area)
• Employ man-portable UAVs
• Employ micro-UAVs

Maneuver to Engage – Cont.

Sea **Neutral**
• None

Sea **Equal**
• Rapidly deploy high-speed, long-range surface vessels (e.g., CVs, CVNs, cruisers etc. carrying cruise missiles, SM-3s, et al- offensive weapons) to operating areas
• Rapidly launch and recover sea-based rotary aircraft
• Receive surface vessel replenishment enroute
• Receive submarine replenishment enroute

Sea **Be Ahead**
• Rapidly launch and recover sea-based supersonic aircraft
• Rapidly launch and recover sea-based subsonic fixed-wing aircraft
• Rapidly launch and recover sea-based STOL aircraft
• Rapidly launch and recover sea-based VSTOL aircraft
• Rapidly deploy USVs from surface vessels
• Rapidly deploy UUVs from surface vessels
• Rapidly deploy high-speed, long-range submarines (ballistic missile or cruise missile launch capability) to operating area

Sea **Be Way Ahead**
• Rapidly launch and recover UCAV on an aircraft carrier (large vessel)
• Rapidly launch and recover UCAV on a cruiser/destroyer (medium size vessel)
• Rapidly launch and recover VSTOL or VTOL UCAV
• Rapidly deploy UUVs from submarines

Maneuver to Engage – Cont.

Land Neutral
• None

Land Equal
• Rapidly employ wheeled, light-attack platforms in unimproved environments
• Rapidly employ wheeled, light-attack platforms in improved environments
• Employ wheeled, light-attack platforms in amphibious environments
• Rapidly employ tracked, light-attack platforms in unimproved environments
• Rapidly employ tracked, light-attack platforms in improved environments
• Employ tracked, light-attack platforms in amphibious environments
• Rapidly employ mechanized, heavy-attack platforms in unimproved environments
• Rapidly employ mechanized, heavy-attack platforms in improved environments
• Rapidly employ surface-to-surface missile platforms in unimproved environments
• Rapidly employ surface-to-surface missile platforms in improved environments
• Rapidly employ surface-to-surface missile platforms in amphibious environments
• Rapidly employ surface-to-surface artillery platforms in unimproved environments
• Rapidly employ surface-to-surface artillery platforms in improved environments
• Rapidly employ surface-to-surface artillery platforms in amphibious environments

Maneuver to Engage – Cont.

Land Be Ahead
• Traverse into and through physically constrained areas with wheeled, light-attack platforms
• Traverse into and through naturally denied areas with wheeled, light-attack platforms
• Traverse into and through physically constrained areas with tracked, light-attack platforms
• Traverse into and through naturally denied areas with tracked, light-attack platforms
• Rapidly employ cushion, light-attack platforms in unimproved environments
• Rapidly employ cushion, light-attack platforms in improved environments
• Employ cushion, light-attack platforms in amphibious environments
• Traverse into and through physically constrained areas with cushion, light-attack platforms
• Traverse into and through naturally denied areas with cushion, light-attack platforms
• Rapidly employ mechanized, heavy-attack platforms in amphibious environments
• Traverse into and through physically constrained areas with mechanized, heavy-attack platforms
• Traverse into and through naturally denied areas with mechanized, heavy-attack platforms
• Traverse into and through physically constrained areas with surface-to-surface missile platforms
• Traverse into and through naturally denied areas with surface-to-surface missile platforms
• Traverse into and through physically constrained areas with surface-to-surface artillery platforms
• Traverse into and through naturally denied areas with surface-to-surface artillery platforms
• Traverse into and through physically constrained areas with UGVs

Land Be Way Ahead
• Traverse into and through naturally denied areas with UGVs

Maneuver to Engage – Cont.

Space Neutral
• None

Space Equal
• Perform maneuvers to separate from launch vehicle
• Perform maneuvers to achieve operational orbit
• Perform maneuvers to separate from launch vehicle

Space Be Ahead
• Perform large and small orbit changes to include both plane and period
• Perform large and small orbit changes to include both plane and period
• Perform large and small orbit changes to include both plane and period

Space Be Way Ahead
• Perform LO separation of weaponized micro-sats from host vehicle
• Perform rapid vehicle trajectory changes to include both plane and period

Maneuver to Engage – Cont.

Cyber Neutral
• None

Cyber Equal
• None

Cyber Be Ahead
• Perform undetected infiltration of computer hardware
• Remotely gain access to a wired LAN network link undetected
• Remotely gain access to a wired WAN network link undetected
• Remotely gain access to a wired ISP link undetected
• Deploy wireless device into wireless broadcast area undetected

Cyber Be Way Ahead
• Remotely access pre-positioned computer in the network undetected
• Remotely access pre-positioned jamming devices undetected
• Remotely access pre-positioned deception devices undetected
• Remotely access pre-positioned grounding weapons undetected
• Remotely access pre-positioned magnetic weapons undetected
• Deploy computer or other hardware to network host location undetected to prepare for network infiltration from the inside
• Perform undetected infiltration of software controlled systems

Engagement Maneuvering

The capability to move in and through the domain of the engagement, be it air, land, sea, space or cyber. Each of these domains were assessed individually and the results reported below.

Air **Neutral**
• None

Air **Equal**
• Perform subsonic employment of air-to-air munitions
• Perform subsonic employment of air-to-ground munitions
• Perform subsonic employment of cruise missiles
• Perform subsonic intercept of high-altitude, subsonic aircraft
• Perform supersonic intercept of high-altitude, subsonic aircraft
• Perform rapid dash to position/reposition
• Perform employment of air-to-air munitions
• Perform employment of air-to-ground munitions
• Perform supersonic intercept of high-altitude, subsonic aircraft BVR
• Perform supersonic intercept of low-altitude, subsonic aircraft BVR
• Perform supersonic intercept of low-altitude cruise missiles
• Employ subsonic, terrain-adhering, long-range cruise missile with mid-course and terminal guidance

Air **Be Ahead**
• Perform rapid dash to position/reposition
• Perform penetration of defended airspace
• Perform Aerial Combat Maneuvering (ACM) against similar aircraft
• Perform Aerial Combat Maneuvering (ACM) against a dissimilar aircraft
• Rapidly launch multiple munitions near-simultaneously
• Operate fixed-wing aircraft from unimproved locations
• Operate fixed-wing aircraft from improved locations other than airfields
• Perform supersonic employment of air-to-air munitions
• Perform supersonic employment of air-to-ground munitions
• Perform supersonic employment of cruise missiles
• Perform subsonic intercept of terrain-adhering, subsonic aircraft
• Perform supersonic intercept of terrain-adhering, subsonic aircraft
• Perform supersonic intercept of terrain-adhering, supersonic aircraft
• Perform supersonic intercept of high-altitude, supersonic aircraft

Engagement Maneuvering – Cont.

Air **Be Ahead – Cont.**
• Perform subsonic intercept of terrain-adhering, subsonic aircraft
• Perform subsonic intercept of cruise missiles
• Perform supersonic intercept of cruise missiles
• Perform energy management for high agility
• Perform Aerial Combat Maneuvering (ACM) against similar aircraft
• Perform Aerial Combat Maneuvering (ACM) against a dissimilar aircraft
• Perform exceptional Nap-of-Earth (NOE) controllability
• Maneuver in a constrained environment
• Rapidly launch multiple munitions near-simultaneously
• Perform supersonic intercept of high-altitude, supersonic aircraft BVR
• Perform supersonic intercept of low-altitude, supersonic aircraft BVR
• Perform supersonic intercept of terrain-adhering, subsonic aircraft BVR
• Perform short-range intercept of enemy aircraft, helicopters, or UAVs with enhanced highly-agile maneuverability with enlarged no-escape zones
• Perform supersonic intercept of high-altitude cruise missiles
• Perform supersonic intercept of terrain-adhering cruise missiles
• Perform mid-course correction, redirection
• Achieve high acceleration off the launch rail for short-range engagements
• Achieve high off-boresight engagement of targets at short-range
• Reject IR countermeasures
• Reject electronic countermeasures
• Reject decoy countermeasures
• Reject UV countermeasures
• Employ precision terminal guidance to minimize Spherical Error Probable (SEP)
• Perform supersonic, air-to-ground munitions mid-course and terminal guidance
• Perform subsonic, air-to-ground munitions mid-course and terminal guidance
• Perform aerodynamic control for delayed effect
• Perform extended/stand-off range engagement
• Self guide undersea mines to precise preprogrammed position
• Reject IR countermeasures
• Reject electronic countermeasures
• Reject decoy countermeasures
• Reject Laser countermeasures
• Employ air-to-air munitions

Engagement Maneuvering – Cont.

Air Be Ahead – Cont.
• Employ air-to-ground munitions
• Perform mid-course correction
• Launch from any environment (sea, air, space, and ground)

Air Be Way Ahead
• Perform exceptional high angle-of-attack (AOA) controllability
• Perform energy management for high-altitude zoom
• Perform energy management for transatmospheric porpoising
• Perform LO employment of air-to-air munitions
• Perform LO employment of air-to-ground munitions
• Perform LO employment of cruise missiles
• Perform supersonic intercept of terrain-adhering, supersonic aircraft BVR
• Perform fire and forget with lock-on after-launch weapons (to make missiles less dependent on the host aircraft's fire-control system)
• Perform laser lock-on and tracking after launch
• Perform pre-launch selectable smart penetration fusing
• Perform hypersonic, air-to-ground munitions mid-course and terminal guidance
• Employ precision terminal guidance to minimize Spherical Error Probable (SEP)
• Perform hypersonic, space-to-terrestrial munitions mid-course and terminal guidance
• Perform fast and agile Aerial Combat Maneuvering (ACM) against other UAVs
• Employ autonomous micro-UAVs in physically constrained areas
• Employ autonomous terminal guidance to penetrate deep within tunnels and other constrained environments
• Employ supersonic, terrain-adhering, long-range cruise missile with mid-course and terminal guidance
• Perform dynamic enroute re-targeting
• Employ precision terminal guidance to minimize Spherical Error Probable (SEP)

Engagement Maneuvering – Cont.

Sea Neutral
• None
• Rapidly deploy mines/captor mines from subsurface/submersible vessels
• Rapidly activate and release encapsulated weapon from captor mine (torpedo or mine)

Sea Equal
• Rapidly employ sea-based Electronic Jamming from surface vessels
• Rapidly launch ballistic missiles from surface vessels
• Rapidly launch cruise missiles from surface vessels
• Rapidly launch torpedoes from surface vessels
• Rapidly launch mines (surface, subsurface, captors, et al) from surface vessels
• Rapidly target, re-target, and fire surface vessel guns
• Rapidly accelerate torpedo and maneuver to point of impact (implies long-range engagement)
• Rapidly turn torpedo to engage (follow) or re-engage target (re-attack)
• Self guide encapsulated weapon to engagement zone at high-speed
• Rapidly launch ballistic or cruise missile while submerged or surfaced
• Rapidly intercept surface and subsurface vessels with submarines

Sea Be Ahead
• Rapidly maneuver and relocate engaged surface vessels for offensive/defensive operational positioning
• Rapidly employ sea-based Directed Energy (DE) from surface vessels
• Rapidly deploy mines/captor mines from surface vessels
• Self guide undersea mines to precise preprogrammed position
• Guide subsurface vessels through restricted waterways
• Rapidly maneuver and relocate subsurface/submersible vessels for operational positioning
• Initiate mine detonation sequence (fuse the mine - contact, pressure, magnetic, acoustic, acoustic signature); includes "counting fuse" (count three targets, activate, and kill the fourth)
• Rapidly launch torpedoes while submerged or surfaced

Engagement Maneuvering – Cont.

Sea **Be Ahead – Cont.**
• Silently launch torpedoes from subsurface/submersible vessels
• Ripple fire/ launch long-range, high-speed torpedoes
• Rapidly deploy mines/captor mines from UUVs
• Traverse into and through denied undersea areas with micro-UUVs
• Rapidly employ littoral assault vehicles in physically constrained areas

Sea **Be Way Ahead**
• Guide high-speed surface vessels in restricted waterways
• Traverse into and through denied sea areas with micro-USVs
• Rapidly employ sea-based, directional, non-nuclear Electro Magnetic Pulse (EMP) from surface vessels
• Self guide USVs in physically constrained areas
• Silently and at high-speed, approach launch basket

Engagement Maneuvering – Cont.

Land Neutral
• None

Land Equal
• Rapidly maneuver, reposition, and employ ground, mobile EW platforms
• Rapidly maneuver, reposition, and employ ground, mobile DE platforms
• Rapidly maneuver, reposition, and employ ground, mobile, directional EMP platforms
• Rapidly maneuver, reposition, and employ indirect-fire, heavy-attack platforms
• Rapidly maneuver, reposition, and employ Tactical Ballistic Missiles
• Rapidly maneuver, reposition, and employ agile, automatic/semi-automatic, mounted weapons
• Rapidly reposition and employ lightweight automatic/semi-automatic dismounted weapons
• Rapidly maneuver, reposition, and employ multiple rocket launch platforms
• Deploy/Fire multiple rockets from a multiple-launch rocket system at a high rate
• Rapidly reposition and employ small, lightweight, automatic/semi-automatic, hand-held weapons
• Rapidly reposition and employ unmounted firearms

Land Be Ahead
• Rapidly maneuver, reposition, and employ direct-fire, heavy-attack platforms
• Rapidly maneuver, reposition, and employ light-attack platforms
• Guide and maintain high dynamic, short-range, line-of-sight surface-to-surface mid-course and terminally guided munitions
• Perform selective orientation of mines

Land Be Way Ahead
• Autonomous UGVs in constrained environments
• Perform small caliber mid-course and terminal guidance

Engagement Maneuvering – Cont.

Space Neutral
• None

Space Equal
• None

Space Be Ahead
• Perform in-flight, autonomous re-targeting
• Perform rapid, high-speed re-entry of weapons/weapons platforms
• Perform in-flight autonomous re-targeting
• Perform small, rapid trajectory changes
• Perform rapid vehicle orientation/attitude changes for precision re-entry
• Perform rapid high-speed re-entry of weapons platforms
• Perform in-flight autonomous re-targeting
• Perform small, rapid trajectory changes
• Perform weapons operation independent of space weather
• Perform small, rapid vehicle orientation/attitude changes for precision MIRV deployment
• Perform rapid, high-speed re-entry of weapons

Space Be Way Ahead
• Perform small, rapid orbit and attitude changes to establish and maintain precise relative position with the intended target (includes station-keeping and pre-weapons employment orientation)
• Perform precise weapon pointing prior to weapons employment (for non-maneuverable weapons such as Directed Energy, RF, and non-steerable munitions and maneuverable weapons such as missiles, CAV, and steerable munitions)
• Perform rapid, LO launch of weapons with minimal impact to satellite inertia
• Perform weapons operation independent of space weather
• Perform high-speed, LO, directional changes of in-flight weapons (for maneuverable weapons such as missiles, CAV, and steerable munitions)

Engagement Maneuvering – Cont.

Space **Be Way Ahead – Cont.**
• Perform autonomous, in-flight guidance and collision avoidance
• Perform terminal guidance to target through countermeasures, including ECM, IRCM, chaff/flares, and decoys
• Perform multi-target engagement sequencing
• Perform small, rapid orbit and attitude changes to establish and maintain precise relative position with the intended target, includes station-keeping and pre-weapons employment orientation
• Perform precise weapon pointing prior to release (for non-maneuverable weapons such as Directed Energy, RF, and non-steerable munitions and maneuverable weapons such as missiles, CAV, and steerable munitions)
• Perform rapid, LO launch of weapons with minimal impact to satellite inertia
• Perform precise in-flight weapon directional changes, including re-entry angle maneuvers for maneuverable weapons such as missiles, CAV, and steerable munitions
• Perform weapons operation independent of space weather
• Perform autonomous in-flight guidance and collision avoidance
• Perform terminal guidance to target through countermeasures, including ECM, IRCM, chaff/flares, and decoys
• Perform multi-target engagement sequencing
• Perform weapons operation independent of space weather
• Perform autonomous, in-flight guidance and collision avoidance
• Perform small, rapid orbit and attitude changes to establish and maintain precise relative position with the intended target for pre-weapons employment orientation
• Perform precise weapon pointing prior to release
• Perform rapid, LO launch of weapons with minimal impact to satellite inertia
• Perform weapons operation independent of space weather
• Perform high-speed, LO, directional changes of in-flight weapon for maneuverable weapons to impact
• Perform autonomous, in-flight guidance and collision avoidance
• Perform terminal guidance to target through countermeasures, including ECM, IRCM, chaff/flares, and decoys
• Perform multi-weapon engagement sequences

Engagement Maneuvering – Cont.

Cyber Neutral
• None

Cyber Equal
• None

Cyber Be Ahead
• Remotely perform undetected infiltration of LAN links through a back door
• Remotely perform undetected infiltration of WAN links through a back door
• Remotely perform undetected infiltration of ISP links through a back door
• Remotely perform undetected infiltration of network appliances through a back door
• Gain access to wireless signal using wireless device located in the wireless broadcast area
• Maneuver through network directly to desired target location
• Transfer file weapon (e-mail, worm, virus, executable, etc.) to target environment and set activation criteria
• Transfer script, command, etc. to target system to prepare for Computer Network Attack

Engagement Maneuvering – Cont.

Cyber **Be Way Ahead**
• Remotely perform undetected infiltration of LAN links through open ports
• Remotely perform undetected infiltration of WAN links through open ports
• Remotely perform undetected infiltration of ISP links through open ports
• Remotely perform undetected infiltration of network appliances through open ports
• Perform undetected infiltration of LAN links from network location (from the inside)
• Perform undetected infiltration of WAN links from network location (from the inside)
• Perform undetected infiltration of ISP links from network location (from the inside)
• Perform undetected infiltration of network appliances from network location (from the inside)
• Remotely activate pre-positioned jamming devices
• Remotely activate pre-positioned deception devices
• Remotely activate pre-positioned magnetic weapon
• Remotely activate pre-positioned grounding weapon
• Maneuver to desired target through multiple computers and systems in a network to prevent/hinder tracing
• Maneuver through target system/computer to desired database, application, storage, etc.

Engagement

The capability to engage (destroy, degrade, deny, disrupt, or deceive) an air, land, sea, space or cyber adversarial target. Each of these target domains were assessed individually and the results reported below.

Defeat Air Target Neutral
• None

Defeat Air Target Equal
• Destroy/Degrade large, high-speed, high-altitude aircraft with HE
• Destroy/Degrade large, high-speed, low-altitude aircraft with HE
• Destroy/Degrade large, low-speed, high-altitude aircraft with HE
• Destroy/Degrade large, low-speed, low-altitude aircraft with HE
• Destroy/Degrade small, high-speed, high-altitude aircraft with HE
• Destroy/Degrade small, high-speed, low-altitude aircraft with HE
• Destroy/Degrade small, low-speed, high-altitude aircraft with HE
• Destroy/Degrade small, low-speed, low-altitude aircraft with HE
• Destroy/Degrade large, high-speed, high-altitude aircraft with Projectiles
• Destroy/Degrade large, high-speed, low-altitude aircraft with Projectiles
• Destroy/Degrade large, low-speed, high-altitude aircraft with Projectiles
• Destroy/Degrade large, low-speed, low-altitude aircraft with Projectiles
• Destroy/Degrade large, low-speed, high-altitude LO aircraft with Projectiles
• Destroy/Degrade large, low-speed, low-altitude LO aircraft with Projectiles
• Destroy/Degrade small, low-speed, high-altitude aircraft with Projectiles
• Destroy/Degrade small, low-speed, low-altitude aircraft with Projectiles
• Deny/Disrupt high-speed, high-altitude aircraft electronics with EW Jamming (radar, communications, navigation)
• Deny/Disrupt high-speed, low-altitude aircraft electronics with EW Jamming (radar, communications, navigation)
• Deny/Disrupt low-speed, low-altitude aircraft electronics with EW Jamming (radar, communications, navigation)
• Deny/Disrupt low-speed, high-altitude aircraft electronics with EW Jamming (radar, communications, navigation)
• Deny/Disrupt high-speed, high-altitude LO aircraft electronics with EW Jamming (radar, communications, navigation)
• Deny/Disrupt low-speed, high-altitude LO aircraft electronics with EW Jamming (radar, communications, navigation)
• Deny/Disrupt high-speed, low-altitude LO aircraft electronics with EW Jamming (radar, communications, navigation)

Engagement – Cont.

Defeat Air Target Equal – Cont.
• Deny/Disrupt low-speed, low-altitude LO aircraft electronics with EW Jamming (radar, communications, navigation)
• Destroy/Degrade large, low-speed, medium--altitude rotary aircraft (helicopter) with HE
• Destroy/Degrade large, low-speed, low-altitude rotary aircraft (helicopter) with HE
• Destroy/Degrade small low-speed, medium-altitude rotary aircraft (helicopter) with HE
• Destroy/Degrade small, low-speed medium-altitude rotary aircraft (helicopter) with a Projectile
• Destroy/Degrade large, low-speed low-altitude rotary aircraft (helicopter) with a Projectile
• Destroy/Degrade large, low-speed medium-altitude rotary aircraft (helicopter) with a Projectile
• Deny/Disrupt rotary aircraft (helicopter) electronics (radar, communications, navigation) with EW Jamming
• Destroy/Degrade large, high-speed, high-altitude UAV (fixed-wing and rotary) with HE
• Destroy/Degrade large, low-speed, high-altitude UAV (fixed-wing and rotary) with HE
• Destroy/Degrade large, low-speed, low-altitude UAV (fixed-wing and rotary) with HE
• Deny/Disrupt low-speed, low-altitude UAV (sensors, communications, navigation) with EW Jamming
• Deny/Disrupt high-speed, high-altitude UAV (radar, communications, navigation) with EW Jamming
• Deny/Disrupt high-speed, low-altitude UAV (radar, communications, navigation) with EW Jamming
• Deny/Disrupt low-speed, high-altitude UAV (radar, communications, navigation) with EW Jamming

Engagement – Cont.

Defeat Air Target **Be Ahead**
• Destroy/Degrade large, high-speed, high-altitude LO aircraft with HE
• Destroy/Degrade large, high-speed, low-altitude LO aircraft with HE
• Destroy/Degrade large, low-speed, high-altitude LO aircraft with HE
• Destroy/Degrade large, low-speed, low-altitude LO aircraft with HE
• Destroy/Degrade large, high-speed, high-altitude LO aircraft with Projectiles
• Destroy/Degrade large, high-speed, low-altitude LO aircraft with Projectiles
• Destroy/Degrade small high-speed, high-altitude aircraft with Projectiles
• Destroy/Degrade small high-speed, low-altitude aircraft with Projectiles
• Destroy/Degrade small high-speed, high-altitude LO aircraft with Projectiles
• Destroy/Degrade small high-speed, low-altitude LO aircraft with Projectiles
• Destroy/Degrade small low-speed, high-altitude LO aircraft with Projectiles
• Destroy/Degrade small low-speed, low-altitude LO aircraft with Projectiles
• Destroy/Degrade/Deny large, high-speed, low-altitude aircraft with DE
• Destroy/Degrade/Deny large, high-speed, high-altitude aircraft with DE
• Destroy/Degrade/Deny large, low-speed, low-altitude aircraft with DE
• Destroy/Degrade/Deny large, low-speed, high-altitude aircraft with DE
• Destroy/Degrade/Deny small high-speed, high-altitude aircraft with DE
• Destroy/Degrade/Deny small high-speed, low-altitude aircraft with DE
• Destroy/Degrade/Deny small low-speed, high-altitude aircraft with DE
• Destroy/Degrade/Deny small low-speed, low-altitude aircraft with DE
• Destroy/Degrade high-speed, high-altitude aircraft with Directional, Non-nuclear Electro Magnetic Pulse (EMP)
• Destroy/Degrade high-speed, low-altitude aircraft with Directional, Non-nuclear Electro Magnetic Pulse (EMP)
• Destroy/Degrade low-speed, high-altitude aircraft with Directional, Non-nuclear Electro Magnetic Pulse (EMP)
• Destroy/Degrade low-speed, low-altitude aircraft with Directional, Non-nuclear Electro Magnetic Pulse (EMP)
• Deceive aircraft sensors with EW Deception
• Destroy/Degrade large, low-speed, medium-altitude LO rotary aircraft (helicopter) with HE
• Destroy/Degrade large, low-speed, low-altitude LO rotary aircraft (helicopter) with HE
• Destroy/Degrade small low-speed, low-altitude rotary aircraft (helicopter) with HE

Engagement – Cont.

Defeat Air Target Be Ahead – Cont.
• Destroy/Degrade small low-speed, medium-altitude LO rotary aircraft (helicopter) with HE
• Destroy/Degrade small low-speed, low-altitude LO rotary aircraft (helicopter) with HE
• Destroy/Degrade small, low-speed, low-altitude rotary aircraft (helicopter) with a Projectile
• Destroy/Degrade small, low-speed, low-altitude LO rotary aircraft (helicopter) with a Projectile
• Destroy/Degrade small, low-speed medium-altitude LO rotary aircraft (helicopter) with a Projectile
• Destroy/Degrade large, low-speed low-altitude LO rotary aircraft (helicopter) with a Projectile
• Destroy/Degrade large, low-speed medium-altitude LO rotary aircraft (helicopter) with a Projectile
• Destroy/Degrade rotary aircraft (helicopter) with Directional, Non-nuclear Electro Magnetic Pulse (EMP)
• Destroy/Degrade large, high-speed, low-altitude UAV (fixed-wing and rotary) with HE
• Destroy/Degrade large, high-speed, high-altitude LO UAV (fixed-wing and rotary) with HE
• Destroy/Degrade large, high-speed, low-altitude LO UAV (fixed-wing and rotary) with HE
• Destroy/Degrade large, low-speed, high-altitude LO UAV (fixed-wing and rotary) with HE
• Destroy/Degrade large, low-speed, low-altitude LO UAV (fixed-wing and rotary) with HE
• Destroy/Degrade small high-speed, high-altitude UAV (fixed-wing and rotary) with HE
• Destroy/Degrade small high-speed, low-altitude UAV (fixed-wing and rotary) with HE
• Destroy/Degrade small low-speed, high-altitude UAV (fixed-wing and rotary) with HE
• Destroy/Degrade small low-speed, low-altitude UAV (fixed-wing and rotary) with HE
• Destroy/Degrade low-speed, low-altitude UAV with a Projectile
• Destroy/Degrade high-speed, low-altitude UAV with a Projectile
• Destroy/Degrade low-speed, high-altitude UAV with a Projectile

Engagement – Cont.

Defeat Air Target Be Ahead – Cont.
• Destroy/Degrade high-speed, high-altitude UAV with a Projectile
• Destroy/Degrade low-speed, low-altitude LO UAV with a Projectile
• Destroy/Degrade high-speed, low-altitude LO UAV with a Projectile
• Destroy/Degrade low-speed, high-altitude LO UAV with a Projectile
• Destroy/Degrade high-speed, high-altitude LO UAV with a Projectile
• Deny/Disrupt low-speed, low-altitude micro-UAV (sensors, communications, navigation) with EW Jamming
• Destroy/Degrade small high-speed, high-altitude cruise missile with HE
• Destroy/Degrade small high-speed, low-altitude cruise missile with HE
• Destroy/Degrade small low-speed, high-altitude cruise missile with HE
• Destroy/Degrade small low-speed, low-altitude cruise missile with HE
• Destroy/Degrade small high-speed, high-altitude cruise missile with Projectiles
• Destroy/Degrade small high-speed, low-altitude cruise missile with Projectiles
• Destroy/Degrade small low-speed, high-altitude cruise missile with Projectiles
• Destroy/Degrade small low-speed, low-altitude cruise missile with Projectiles
• Destroy/Degrade small high-speed, high-altitude LO cruise missile with Projectiles
• Destroy/Degrade small high-speed, low-altitude LO aircraft with Projectiles
• Destroy/Degrade small low-speed, high-altitude LO cruise missile with Projectiles
• Destroy/Degrade small low-speed, low-altitude LO cruise missile with Projectiles
• Deny/Disrupt low-speed, low-altitude cruise missile with electronics (radar, communications, navigation) with EW Jamming
• Deny/Disrupt low-speed, high-altitude cruise missile with electronics (radar, communications, navigation) with Electronic Jamming
• Deny/Disrupt high-speed, low-altitude cruise missile electronics (radar, communications, navigation) with EW Jamming
• Deny/Disrupt high-speed, high-altitude cruise missile electronics (radar, communications, navigation) with EW Jamming
• Destroy/Degrade low-speed, low-altitude cruise missile with Directional, Non-nuclear Electro Magnetic Pulse (EMP)
• Destroy/Degrade low-speed, high-altitude cruise missile with Directional, Non-nuclear Electro Magnetic Pulse (EMP)
• Destroy/Degrade high-speed, low-altitude cruise missile with Directional, Non-nuclear Electro Magnetic Pulse (EMP)

Engagement – Cont.

Defeat Air Target Be Ahead – Cont.
• Destroy/Degrade high-speed, high-altitude cruise missile with Directional, Non-nuclear Electro Magnetic Pulse (EMP)
• Deceive cruise missile sensors with EW Jamming

Defeat Air Target Be Way Ahead
• Destroy/Degrade small high-speed, high-altitude LO aircraft with HE
• Destroy/Degrade small high-speed, low-altitude LO aircraft with HE
• Destroy/Degrade small low-speed, high-altitude LO aircraft with HE
• Destroy/Degrade small low-speed, low-altitude LO aircraft with HE
• Destroy/Degrade/Deny large, high-speed, high-altitude LO aircraft with DE
• Destroy/Degrade/Deny large, high-speed, low-altitude LO aircraft with DE
• Destroy/Degrade/Deny large, low-speed, high-altitude LO aircraft with DE
• Destroy/Degrade/Deny large, low-speed, low-altitude LO aircraft with DE
• Destroy/Degrade/Deny small high-speed, high-altitude LO aircraft with DE
• Destroy/Degrade/Deny small high-speed, low-altitude LO aircraft with DE
• Destroy/Degrade/Deny small low-speed, high-altitude LO aircraft with DE
• Destroy/Degrade/Deny small low-speed, low-altitude LO aircraft with DE
• Destroy/Degrade/Deny aircraft sensors with DE
• Hijack aircraft with Computer Network Attack
• Destroy/Degrade low-speed, low-altitude rotary aircraft (helicopter) with DE
• Destroy/Degrade low-speed, medium-altitude rotary aircraft (helicopter) with DE
• Destroy/Degrade low-speed, low-altitude LO rotary aircraft (helicopter) with DE
• Deceive rotary aircraft (helicopter) sensors with EW Deception
• Destroy/Degrade/Deny rotary aircraft (helicopter) sensors with DE
• Hijack rotary aircraft with Computer Network Attack
• Destroy/Degrade small high-speed, high-altitude LO UAV (fixed-wing and rotary) with HE
• Destroy/Degrade small high-speed, low-altitude LO UAV (fixed-wing and rotary) with HE
• Destroy/Degrade small low-speed, high-altitude LO UAV (fixed-wing and rotary) with HE
• Destroy/Degrade small low-speed, low-altitude LO UAV (fixed-wing and rotary) with HE

Engagement – Cont.

Defeat Air Target Be Way Ahead – Cont.
• Destroy/Degrade/Deny low-speed, low-altitude UAV with DE
• Destroy/Degrade/Deny low-speed, high-altitude UAV with DE
• Destroy/Degrade/Deny high-speed, low-altitude UAV with DE
• Destroy/Degrade/Deny high-speed, high-altitude UAV with DE
• Destroy/Degrade/Deny low-speed, low-altitude LO UAV with DE
• Destroy/Degrade/Deny low-speed, high-altitude LO UAV with DE
• Destroy/Degrade/Deny high-speed, low-altitude LO UAV with DE
• Destroy/Degrade/Deny high-speed, high-altitude LO UAV with DE
• Deceive UAV (radar, communications, navigation) with EW Deception
• Deceive UAV (radar, communications, navigation) with Computer Network Attack
• Hijack UAV with Computer Network Attack
• Destroy/Degrade low-speed, low-altitude micro-UAV with HE
• Destroy/Degrade low-speed, low-altitude micro-UAV with Projectiles
• Destroy/Degrade/Deny low-speed, low-altitude micro-UAV with DE
• Deceive low-speed, low-altitude micro-UAV (communications, navigation) with EW Deception
• Destroy/Degrade small high-speed, high-altitude LO cruise missile with HE
• Destroy/Degrade small high-speed, low-altitude LO cruise missile with HE
• Destroy/Degrade small low-speed, high-altitude LO cruise missile with HE
• Destroy/Degrade small low-speed, low-altitude LO cruise missile with HE
• Destroy/Degrade/Deny low-speed, low-altitude cruise missile with DE
• Destroy/Degrade/Deny low-speed, high-altitude cruise missile with DE
• Destroy/Degrade/Deny high-speed, high-altitude cruise missile with DE
• Destroy/Degrade/Deny high-speed, low-altitude cruise missile with DE
• Destroy/Degrade/Deny high-speed, high-altitude LO missile with DE
• Destroy/Degrade/Deny high-speed, low-altitude LO missile with DE
• Destroy/Degrade/Deny low-speed, low-altitude LO missile with DE
• Destroy/Degrade/Deny low-speed, high-altitude LO missile with DE
• Destroy/Degrade/Deny cruise missile sensors with DE
• Hijack cruise missiles with Computer Network Attack

Engagement – Cont.

Defeat Sea Target Neutral
• None

Defeat Sea Target Equal
• Destroy/Degrade fixed-wing and rotary carriers (aircraft carriers) with HE
• Destroy/Degrade heavy cruisers/destroyers (armored) with HE
• Destroy/Degrade destroyers/frigates with HE
• Deny/Disrupt surface vessel communication/navigation with EW Jamming
• Deny/Disrupt surface vessel target sensors with EW Jamming
• Deny a large surface vessel access to a port/harbor with obstructions (barriers, barricades, etc.)
• Destroy/Degrade small, low-speed surface vessel with HE
• Destroy/Degrade small, low-speed surface vessel with a Projectile
• Destroy/Degrade small, high-speed surface vessel with a Projectile
• Deny/Disrupt small vessel communication/navigation with EW Jamming
• Destroy/Degrade surface submersible with a Projectile
• Deny a small surface vessel access to a port/harbor with obstructions (barriers, barricades, etc.)
• Destroy/Degrade small, rigid, inflatable, high-speed boat with HE
• Destroy/Degrade small, rigid, inflatable, high-speed boat with a Projectiles
• Deny/Disrupt large submarine surface communications/navigation/radar with EW Jamming
• Deny/Disrupt large submarine subsurface communications/navigation with EW Jamming
• Deny/Disrupt small submarine communications/navigation with EW Jamming
• Deny undersea vehicle access to port/harbor with obstructions (barriers, barricades)
• Destroy/Degrade undersea platforms with HE
• Destroy/Degrade undersea tunnels and caves with HE
• Destroy/Degrade piers with HE
• Destroy/Degrade piers with a Projectile
• Destroy/Degrade coastal repair facilities with HE
• Destroy/Degrade/Deny/Disrupt coastal repair facilities with a Projectile
• Deny/Disrupt surface or near-surface sea sensors with EW Jamming

Engagement – Cont.

Defeat Sea Target Equal – Cont.
• Destroy/Degrade enemy barriers, barricades, obstacles that extend from the surface to the depths with HE
• Destroy/Degrade enemy surface obstructions with HE
• Deny/Disrupt sea-based communication/navigation with EW Jamming
• Deny/Disrupt sea-based target sensors with EW Jamming
• Destroy/Degrade undersea support structures (bridge or pier supports) with HE
• Destroy/Degrade undersea acoustic sensors with HE
• Destroy/Degrade undersea magnetic sensors with HE
• Destroy undersea barriers, barricades, obstacles with HE
• Kill/Wound undersea combatants with HE
• Kill/Wound undersea combatants with a Projectile
• Control access to undersea combatants with barriers and obstacles

Defeat Sea Target Be Ahead
• Destroy/Degrade/Deny fixed-wing and rotary carriers (aircraft carriers) with DE
• Destroy/Degrade/Deny heavy cruisers/destroyers (armored) with DE
• Destroy/Degrade/Deny destroyers/frigates with DE
• Destroy/Degrade LO vessels with HE
• Deny/Disrupt surface vessel acoustic sensors with Acoustic Jamming
• Deceive surface vessel communication/navigation/sensors with EW Deception
• Deny a large surface vessel access to a port/harbor with HE (mines)
• Deny a large surface vessel access to an open ocean area with HE (mines)
• Destroy/Degrade small, high-speed surface vessel with HE
• Destroy/Degrade/Deny small, low-speed surface vessel with DE
• Destroy/Degrade small, high-speed LO surface vessel with HE
• Destroy/Degrade small, low-speed LO surface vessel with HE
• Destroy/Degrade small, high-speed LO surface vessel with a Projectiles
• Destroy/Degrade small, low-speed LO surface vessel with a Projectiles
• Deceive small vessel with EW Deception
• Destroy/Degrade surface submersible with HE
• Deny a small surface vessel access to a port/harbor with HE (mines)
• Deny a small surface vessel access to an open ocean area with HE (mines)

Engagement – Cont.

Defeat Sea Target Be Ahead – Cont.
• Destroy/Degrade large submarine with HE
• Deny/Disrupt large submarine acoustic sensors with Acoustic Weapons
• Deceive large submarine acoustic sensors with Acoustic Weapons
• Deny/Disrupt large submarine magnetic sensors
• Destroy/Degrade small submarine with HE
• Deny/Disrupt small submarine acoustic sensors with Acoustic Weapons
• Deceive small submarine acoustic sensors with Acoustic Weapons
• Destroy/Degrade small unmanned undersea vehicle with HE
• Deny/Disrupt small unmanned undersea vehicle acoustic sensors
• Deceive small unmanned undersea vehicle acoustic sensors
• Deny/Disrupt small unmanned undersea vehicle magnetic sensors
• Deceive small unmanned undersea vehicle magnetic sensors
• Deny/Disrupt small unmanned undersea vehicle communications/navigation (communications for C2)
• Deny undersea vehicle access to port/harbor with HE (mines)
• Deny undersea vehicle access to an open ocean areas with HE (mines)
• Deny/Disrupt undersea/ocean floor acoustics sensors with Acoustic Jamming
• Deny/Disrupt undersea/ocean floor magnetic sensors with Magnetic Jamming
• Deceive enemy undersea/ocean floor acoustics sensors with Acoustic Weapons
• Deceive enemy undersea/ocean floor magnetic sensors with Magnetic Weapons
• Deny/Disrupt piers with non-lethal chemical weapons (sticky foams or similar technique)
• Destroy/Degrade coastal repair facilities with corrosives
• Destroy/Degrade coastal repair facilities with Directional, Non-nuclear EMP
• Deny/Disrupt coastal repair facilities with non-lethal chemical weapons
• Deceive surface or near-surface sea sensors with EW Deception
• Deny/Disrupt surface or near-surface sea sensors with Acoustic Weapons
• Destroy/Degrade/Deny sea-based target sensors with DE
• Deceive sea-based communication/navigation/sensors with EW Deception
• Deny/Disrupt undersea acoustic sensors with Acoustic Weapons
• Kill/Wound undersea combatants with Acoustic Weapons
• Deter/Control maritime non-combatants access to maritime units (e.g., civilians on boats) with non-lethal weapons (acoustic, etc.)
• Deter/Control maritime non-combatants access to maritime facilities (e.g., civilians on boats) with non-lethal weapons (acoustic, etc.)

Engagement – Cont.

Defeat Sea Target Be Way Ahead
• Destroy/Degrade/Deny LO vessels with DE
• Destroy/Degrade/Deny surface vessel target sensors with DE
• Destroy/Degrade/Deny small, high-speed surface vessel with DE
• Deny/Disrupt small, high-speed LO surface vessel with DE
• Deny/Disrupt small, low-speed LO surface vessel with DE
• Destroy/Degrade/Deny surface submersible with DE
• Destroy/Degrade/Deny small, rigid, inflatable, high-speed boat with DE
• Deny/Disrupt/Deceive a large submarine with Computer Network Attack
• Hijack a large submarine with Computer Network Attack

Engagement – Cont.

Defeat Land Target Neutral
• Destroy/Degrade drug propagation environment (i.e., destroy drug crops, or destroy ability to grow drug crop) with HE (defoliation, etc.)
• Destroy/Degrade barriers, barricades, breeches, obstacles with HE

Defeat Land Target Equal
• Destroy/Degrade an unhardened building with HE
• Deny/Disrupt an unhardened building with non-lethal or limited-use chemical weapons
• Destroy/Degrade hardened structures with HE
• Destroy/Degrade ground station antenna fields (part of communication network nodes) with HE
• Destroy/Degrade highways with HE
• Destroy/Degrade bridges (road and rail) with HE
• Destroy/Degrade bridges (road and rail) with Projectiles
• Destroy/Degrade tunnels (road and rail) with HE
• Destroy/Degrade rail line (railroad track) with HE
• Destroy/Degrade airport runways with HE
• Destroy/Degrade soft area target with HE
• Destroy/Degrade power production sources with HE
• Destroy/Degrade power transmission sources with HE
• Destroy/Degrade ground sensors/sensor networks with HE
• Destroy/Degrade IADS acquisition and search, tracking, and fire control radars/sensors with HE
• Destroy/Degrade POL production and storage sources with HE
• Destroy/Degrade fixed artillery systems with HE
• Destroy/Degrade mobile ground sensors with HE
• Destroy/Degrade movable ground stations with HE
• Destroy/Degrade mobile command posts (trucks and trailers) with HE
• Destroy/Degrade/Deny use of area with HE (mines)
• Destroy/Degrade drug propagation environment (i.e., destroy drug crops, or destroy ability to grow drug crop) with non-lethal chemical weapons (defoliation, etc.)
• Destroy/Degrade adversary access to lodgment areas (beach heads, drop zones) with HE (mines)

Engagement – Cont.

Defeat Land Target Equal – Cont.
• Destroy/Degrade fixed missile systems with HE
• Destroy/Degrade land-based mobile launch systems with HE
• Destroy/Degrade manned unarmored vehicles with HE
• Destroy/Degrade manned unarmored vehicles with Projectiles
• Destroy/Degrade unmanned unarmored vehicles with HE
• Destroy/Degrade nuclear weapons with HE
• Destroy/Degrade nuclear weapons with nuclear weapons
• Destroy/Degrade nuclear weapons storage facilities with HE
• Destroy/Degrade nuclear weapon storage facilities using other nuclear weapons
• Destroy/Degrade chemical/biological/radiological weapons with HE
• Destroy/Degrade chemical/biological/radiological weapons with nuclear weapons
• Destroy/Degrade chemical/biological/radiological weapon storage facilities using HE
• Destroy/Degrade chemical/biological/radiological weapon storage facilities using nuclear weapons
• Kill/Wound individual combatant in urban environment with a HE
• Kill/Wound individual combatant in urban environment with a Projectile
• Kill/Wound individual combatant in rural environment with a HE
• Kill/Wound individual combatant in rural environment with a Projectile
• Kill/Wound combatants (troop concentration) in urban environment with a HE
• Kill/Wound combatants (troop concentration) in urban environment with a Projectile
• Kill/Wound combatants (troop concentration) in urban environment with an overpressure weapon
• Deceive combatants (troop concentration) in urban environment with leaflets
• Deceive combatants (troop concentration) in urban environment with television communications
• Deceive combatants (troop concentration) in urban environment with radio communications
• Kill/Wound combatants (troop concentration) in rural environment with HE
• Kill/Wound combatants (troop concentration) in urban environment with a Projectile
• Kill/Wound combatants (troop concentration) in rural environment with an overpressure weapon
• Deceive combatants (troop concentration) in rural environment with leaflets

Engagement – Cont.

Defeat Land Target Equal – Cont.
• Deceive combatants (troop concentration) in rural environment with television communications
• Deceive combatants (troop concentration) in rural environment with radio communications
• Kill/Wound combatants (troop concentration) in open environment with HE
• Kill/Wound combatants (troop concentration) in open environment with a Projectiles
• Kill/Wound combatants (troop concentration) in open environment with overpressure weapon
• Deceive combatants (troop concentration) in open environment with physical communications (leaflets)
• Deceive combatants (troop concentration) in open environment with television communications
• Deceive combatants (troop concentration) in open environment with radio communications
• Kill/Wound combatants (troop concentration) in forested/canopy environment with HE
• Kill/Wound combatants (troop concentration) in forested/canopy environment with a Projectiles
• Kill/Wound combatants (troops) revetment/trench line with HE
• Kill/Wound combatants (troops) revetment/trench line with a Projectiles
• Kill/Wound combatants (troops) revetment/trench line with overpressure weapon
• Deceive combatants (multiple combatants) collocated with non-combatants with physical communications (leaflets)
• Influence non-combatant (population) in urban environment with leaflets
• Influence non-combatant (population) in urban environment with television communications
• Influence non-combatant (population) in urban environment with radio communications
• Influence non-combatant (population) in rural environment with physical communications (leaflets)
• Influence non-combatant (population) in rural environment with television communications
• Influence non-combatant (population) in rural environment with radio communications

Engagement – Cont.

Defeat Land Target **Be Ahead**
• Deny/Disrupt an unhardened building with an overpressure weapon
• Deny/Disrupt an unhardened building with Directional, Non-nuclear EMP
• Destroy/Degrade access to hardened structures with HE
• Deny/Disrupt hardened structures with overpressure weapon
• Destroy/Degrade/Deny ground stations with DE
• Deny/Disrupt ground stations with EW Jamming
• Destroy/Degrade ground stations with Directional, Non-nuclear EMP
• Destroy/Degrade/Deny ground station antenna fields (part of communication network nodes) with DE
• Destroy/Degrade ground station antenna fields (part of communication network nodes) with Directional, Non-nuclear EMP
• Destroy/Degrade soft area target with Directional, Non-nuclear EMP
• Destroy/Degrade/Deny power production sources with DE
• Destroy/Degrade/Deny power transmission sources with DE
• Destroy/Degrade ground sensors/sensor networks with over-pressure weapons
• Destroy/Degrade/Deny ground sensors/sensor networks with DE
• Deny/Disrupt ground sensors/sensor networks with EW Jamming
• Deceive ground sensors/sensor networks with EW Deception
• Destroy/Degrade ground sensors/sensor networks with Directional, Non-nuclear EMP
• Destroy/Degrade/Deny IADS acquisition and search, tracking, and fire control radars/sensors with DE
• Deny/Disrupt IADS acquisition and search, tracking, and fire control radars/sensors with EW Jamming
• Degrade/Destroy IADS acquisition and search, tracking, and fire control radars/sensors with Directional, Non-nuclear EMP
• Destroy/Degrade IADS GCI center tracking and fire control radars/sensors with Directional, Non-nuclear EMP
• Destroy/Degrade POL production and storage with DE
• Destroy/Degrade POL production and storage facilities with EMP
• Destroy/Degrade/Deny fixed artillery systems with DE
• Destroy/Degrade fixed artillery systems with Directional, Non-nuclear EMP
• Destroy/Degrade/Disrupt mobile ground sensors with DE
• Deny/Disrupt mobile ground sensors with EW Jamming
• Deceive mobile ground sensors with EW Deception

Engagement – Cont.

Defeat Land Target Be Ahead – Cont.
• Degrade/Destroy mobile ground sensors with Directional, Non-nuclear EMP
• Destroy/Degrade/Deny movable ground stations with DE
• Deny/Disrupt movable ground stations with EW Jamming
• Destroy/Degrade movable ground stations with Directional, Non-nuclear EMP
• Destroy/Degrade/Deny mobile command posts (trucks and trailers) with DE
• Deny/Disrupt mobile command posts (trucks and trailers) with EW Jamming
• Deny/Disrupt mobile command posts (trucks and trailers) with EW Deception
• Destroy/Degrade mobile command posts (trucks and trailers) with Directional, Non-nuclear EMP
• Destroy deeply buried bunker with a nuclear weapon
• Destroy/Degrade multi-level basement (part of a bunker) with HE
• Destroy/Degrade multi-level basement (part of bunkers) with overpressure weapons
• Destroy deeply buried tunnel or inner-mountain complex with a nuclear weapon
• Destroy a deeply buried missile silo with a nuclear weapon
• Destroy/Degrade cave/cave complex with non-nuclear over-pressure weapon
• Deny use of cave/cave complex with acoustic weapons
• Destroy/Degrade use of below-ground natural passage with HE weapons
• Deny/Disrupt use of area with acoustic weapons
• Deny/Disrupt adversary access to lodgment areas (beach heads, drop zones) with acoustic weapons
• Deny/Disrupt adversary access to lodgment areas (beach heads, drop zones) with non-nuclear EMP
• Degrade/Destroy/Deny fixed missile systems with DE
• Deny/Disrupt fixed missile systems with EW Jamming
• Deceive fixed missile systems with EW Deception
• Degrade/Destroy fixed missile systems with Directional, Non-nuclear EMP
• Destroy/Degrade/Deny land-based mobile launch systems with DE
• Deny/Disrupt land-based mobile launch systems with EW Jamming
• Deceive land-based mobile launch systems with EW Deception
• Destroy/Degrade land-based mobile launch systems with Directional, Non-nuclear EMP
• Destroy/Degrade manned armored vehicles with HE
• Destroy/Degrade/Deny manned armored vehicles with DE
• Deny/Disrupt manned armored vehicles with EW Jamming

Engagement – Cont.

Defeat Land Target **Be Ahead – Cont.**
• Deceive manned armored vehicles with EW Deception
• Destroy/Degrade manned armored vehicles with Directional, Non-nuclear EMP
• Destroy/Degrade unmanned armored vehicles with HE
• Destroy/Degrade/Deny unmanned armored vehicles with DE
• Deny/Disrupt unmanned armored vehicles with EW Jamming
• Deceive unmanned armored vehicles with EW Deception
• Destroy/Degrade unmanned armored vehicles with Directional, Non-nuclear EMP
• Destroy/Degrade/Deny manned unarmored vehicles with DE
• Deny/Disrupt manned unarmored vehicles with EW Jamming
• Deceive manned unarmored vehicles with EW Deception
• Destroy/Degrade manned unarmored vehicles with Directional, Non-nuclear EMP
• Destroy/Degrade/Deny unmanned unarmored vehicles with DE
• Deny/Disrupt unmanned unarmored vehicles with EW Jamming
• Deceive unmanned unarmored vehicles with EW Deception
• Destroy/Degrade unmanned unarmored vehicles with Directional, Non-nuclear EMP
• Destroy/Degrade/Deny nuclear weapons with DE
• Deny/Disrupt nuclear weapons control with EW Jamming
• Deceive nuclear weapons control with EW Deception
• Destroy/Degrade nuclear weapons control with Directional, Non-nuclear EMP
• Destroy/Degrade nuclear weapon storage facilities using Directional, Non-nuclear EMP
• Destroy/Degrade chemical/biological/radiological weapons with DE
• Destroy/Degrade/Deny chemical/biological/radiological weapons control with DE
• Deny/Disrupt chemical/biological/radiological weapons control with EW Jamming
• Destroy/Degrade chemical/biological/radiological weapons control with Directional, Non-nuclear EMP
• Destroy/Degrade chemical/biological/radiological weapon storage facilities using Directional, Non-nuclear EMP
• Destroy/Degrade storage of deeply buried using nuclear weapons
• Kill/Wound combatant (individual) collocated with non-combatants with a Projectile with no collateral damage

Engagement – Cont.

Defeat Land Target Be Ahead – Cont.
• Kill/Wound/Deter individual combatant in urban environment with DE
• Kill/Wound individual combatant in urban environment with overpressure weapon
• Kill/Wound/Deter individual combatant in rural environment with DE
• Kill/Wound individual combatant in rural environment with overpressure weapon
• Deter/Control combatants (troop concentration) in urban environment with a non-lethal chemical weapon
• Deter/Control non-combatants (population) in urban environment with non-lethal chemical weapons (sticky foam or similar technique)
• Deter/Control combatants (troop concentration) in rural environment with a non-lethal chemical weapon
• Deter/Control non-combatants (population) in rural environment with non-lethal chemical weapons (sticky foam or similar technique)
• Deter/Control combatants (troop concentration) in open environment with non-lethal chemical weapons (stick foam)
• Deter/Control combatants (troop concentration) in forested/canopy environment with non-lethal chemical weapons
• Kill/Wound combatants (troop concentration) in forested/canopy environment with overpressure weapons
• Deter/Control combatants (troop concentration) in forested/canopy environment with acoustic weapons
• Deter/Control combatants with non-lethal chemical weapons
• Deter/Control combatants with acoustic weapons
• Kill/Wound combatants (multiple combatants) collocated with non-combatants with HE with minimal lethal collateral damage
• Kill/Wound combatants (multiple combatants) collocated with non-combatants with a Projectile with minimal lethal collateral damage
• Deter/Control combatants (multiple combatants) collocated with non-combatants with non-lethal chemical weapons (sticky foam or similar technique)
• Deter/Control combatants (multiple combatants) collocated with non-combatants with over-pressure weapon
• Deter/Control non-combatant (population) in urban environment with non-lethal chemical weapons (sticky foam or similar technique)
• Deter/Control non-combatant (population) in urban environment with acoustic weapons

Engagement – Cont.

Defeat Land Target Be Ahead – Cont.
• Deter/Control non-combatant (population) in rural environment with non-lethal weapons (sticky foams or similar technique)
• Deter/Control non-combatant (population) in rural environment with acoustic weapons

Defeat Land Target Be Way Ahead
• Destroy/Degrade a specific room with HE and minimize damage to other remaining rooms and floors in an unhardened building
• Destroy/Degrade a specific level of a basement with HE (i.e., target the 2nd level of a multi-level basement) in an unhardened building
• Deny/Disrupt a specific room with an overpressure weapon in a unhardened building
• Destroy/Degrade access to hardened structures with HE with no or limited collateral damage to surrounding structures
• Deny access to hardened structure with Computer Network Attack
• Disrupt access to hardened structure with Computer Network Attack
• Deceive access to hardened structure with Computer Network Attack
• Destroy/Degrade ground station antenna fields (part of communication network nodes) with special corrosives
• Destroy/Degrade highways with HE with non-lethal chemical weapons (sticky foams or similar technique)
• Deny/Disrupt bridges (road and rail) with non-lethal chemical weapons (sticky foams or similar technique)
• Deny/Disrupt tunnels (road and rail) with non-lethal chemical weapons (sticky foams or similar technique)
• Destroy/Degrade rail line (railroad track) with special corrosives
• Deny/Disrupt rail line (railroad track) with non-lethal chemical weapons (sticky foam or similar technique)
• Deny/Disrupt airport runways with non-lethal chemical weapons (sticky foam or similar technique)
• Deny/Disrupt soft area target with non-lethal or limited-use chemical weapons
• Destroy/Degrade power production sources with Directional, Non-nuclear EMP
• Deny/Disrupt access to power production facilities with non-lethal chemical weapons
• Destroy/Degrade power transmission sources with special corrosives

Engagement – Cont.

Defeat Land Target Be Way Ahead – Cont.
• Destroy/Degrade power transmission sources with Directional, Non-nuclear EMP
• Destroy/Degrade/Deny power transmission sources with special conducting weapons
• Deny ground sensors/sensor networks with Computer Network Attack
• Disrupt ground sensors/sensor networks with Computer Network Attack
• Deceive ground sensors/sensor networks with Computer Network Attack
• Deny IADS acquisition and search, tracking, and fire control radars/sensors with Computer Network Attack
• Disrupt IADS acquisition and search, tracking, and fire control radars/sensors with Computer Network Attack
• Deceive IADS acquisition and search, tracking, and fire control radars/sensors with Computer Network Attack
• Deny IADS GCI center tracking and control radars/sensors with Computer Network Attack
• Disrupt IADS GCI center tracking and control radars/sensors with Computer Network Attack
• Deceive IADS GCI center tracking and control radars/sensors with Computer Network Attack
• Destroy/Degrade POL production or storage components with HE with limited damage to other supporting components
• Deny/Disrupt POL production and storage sources with non-lethal chemical weapons
• Destroy/Degrade POL production and storage sources with corrosives/foams
• Deny POL production and storage facilities with Computer Network Attack
• Disrupt POL production and storage facilities with Computer Network Attack
• Deceive POL production and storage facilities with Computer Network Attack
• Deny/Disrupt fixed artillery systems with non-lethal chemical weapons
• Destroy/Degrade mobile ground sensors with HE with no or limited collateral damage to surrounding structures or equipment
• Destroy/Degrade/Disrupt mobile ground sensors with DE with no or limited collateral damage to surrounding structures or equipment
• Deny mobile ground sensors with Computer Network Attack
• Disrupt mobile ground sensors with Computer Network Attack
• Deceive mobile ground sensors with Computer Network Attack

Engagement – Cont.

Defeat Land Target Be Way Ahead – Cont.
• Destroy/Degrade movable ground stations with HE with no or limited damage to surrounding structures or vehicles
• Deny/Disrupt movable ground stations with non-lethal or limited-use chemical weapons
• Deny movable ground stations with Computer Network Attack
• Disrupt movable ground stations with Computer Network Attack
• Deceive movable ground stations with Computer Network Attack
• Deny mobile command posts (trucks and trailers) with Computer Network Attack
• Disrupt mobile command posts (trucks and trailers) with Computer Network Attack
• Deceive mobile command posts (trucks and trailers) with Computer Network Attack
• Deny/Disrupt mobile command posts (trucks and trailers) with non-lethal or limited-use chemical weapons
• Destroy/Degrade deeply buried bunkers with HE
• Deny deeply buried bunkers with Computer Network Attack
• Disrupt deeply buried bunkers with Computer Network Attack
• Deceive deeply buried bunkers with Computer Network Attack
• Destroy/Degrade entry/exit points to/from bunkers with HE
• Destroy /Degrade entry/exit points to/from bunkers with non-lethal or limited-use chemical weapons
• Deny entry/exit points to/from bunkers with Computer Network Attack
• Disrupt entry/exit points to/from bunkers with Computer Network Attack
• Deceive entry/exit points to/from bunkers with Computer Network Attack
• Destroy/Degrade selected level of multi-level basement (part of a bunker) with HE
• Deny/Disrupt multi-level basement (part of bunkers) with non-lethal or limited-use chemical weapons
• Deny multi-level basement (part of bunkers) with Computer Network Attack
• Disrupt multi-level basement (part of bunkers) with Computer Network Attack
• Deceive multi-level basement (part of bunkers) with Computer Network Attack
• Destroy a deeply buried missile silo with HE
• Destroy/Degrade cave/cave complex with HE
• Deny/Disrupt cave/cave complex with non-lethal chemical weapons (sticky foams or similar technique)

Engagement – Cont.

Defeat Land Target **Be Way Ahead – Cont.**
• Deny use of cave/cave complex with non-lethal chemical weapons
• Deny/Disrupt use of below-ground natural passage with non-lethal chemical weapons (sticky foams or similar technique)
• Destroy/Degrade use of below-ground natural passage with non-nuclear over-pressure weapons
• Deny/Disrupt use of below-ground natural passage with acoustic weapons
• Deny/Disrupt use of area with non-lethal chemical weapons
• Deny/Disrupt adversary access to lodgment areas (beach heads, drop zones) with non-lethal chemical weapons
• Destroy/Degrade fixed missile systems with corrosives
• Deny/Disrupt fixed missile systems with non-lethal chemical weapons
• Deny land-based fixed missile systems with Computer Network Attack
• Disrupt land-based fixed missile systems with Computer Network Attack
• Deceive land-based fixed missile systems with Computer Network Attack
• Destroy/Degrade land-based mobile launch systems with corrosives
• Deny land-based mobile launch systems with Computer Network Attack
• Disrupt land-based mobile launch systems with Computer Network Attack
• Deceive land-based mobile launch systems with Computer Network Attack
• Deny/Disrupt manned armored vehicles with non-lethal chemical weapons
• Destroy/Degrade manned armored vehicles with corrosives
• Destroy/Degrade unmanned armored vehicles with corrosives
• Deny/Disrupt manned unarmored vehicles with non-lethal chemical weapons
• Destroy/Degrade manned unarmored vehicles with corrosives
• Destroy/Degrade unmanned unarmored vehicles with corrosives
• Deceive/Disrupt/Deny/Degrade nuclear weapons control with Computer Network Attack
• Hijack nuclear weapons control with Computer Network Attack
• Deny nuclear weapons storage facilities with Computer Network Attack
• Disrupt nuclear weapons storage facilities with Computer Network Attack
• Deceive nuclear weapons storage facilities with Computer Network Attack
• Hijack nuclear weapons storage facilities with Computer Network Attack
• Deny chemical/biological/radiological weapons control with Computer Network Attack
• Disrupt chemical/biological/radiological weapons control with Computer Network Attack

Engagement – Cont.

Defeat Land Target Be Way Ahead – Cont.
• Deceive chemical/biological/radiological weapons control with Computer Network Attack
• Hijack chemical/biological/radiological weapons control with Computer Network Attack
• Deny chemical/biological/radiological weapons storage facilities with Computer Network Attack
• Disrupt chemical/biological/radiological weapons storage facilities with Computer Network Attack
• Deceive chemical/biological/radiological weapons storage facilities with Computer Network Attack
• Destroy/Degrade storage of WMDs in hardened bunkers with HE
• Destroy/Degrade storage of WMDs in hardened bunkers using nuclear weapons
• Destroy/Degrade storage of deeply buried WMDs with HE
• Kill/Wound/Control combatant (individual) collocated with non-combatants with DE with no collateral damage
• Deceive combatant (individual) collocated with non-combatants with electronic communications (e-mail)
• Deter/Control combatant (individual) collocated with non-combatants with non-lethal chemical weapons (sticky foam or similar technique)
• Deceive individual combatant in urban environment with electronic communications (e-mail)
• Deter/Control individual combatant in urban environment with non-lethal chemical weapons (sticky foams or similar technique)
• Deceive individual combatant in rural environment with electronic communications (e-mail)
• Deter/Control individual combatant in urban environment with non-lethal chemical weapons (sticky foams or similar technique)
• Deny computer user (i.e., decision maker) with Computer Network Attack (virus, e-mail, etc.)
• Disrupt computer user (i.e., decision maker) with Computer Network Attack (virus, e-mail, etc.)
• Deceive computer user (i.e., decision maker) with Computer Network Attack (virus, e-mail, etc.)
• Kill/Wound combatants (multiple combatants) collocated with non-combatants with DE with minimal lethal collateral damage

Engagement – Cont.

Defeat Space Target Neutral
• None

Defeat Space Target Equal
• Destroy/Degrade on-orbit facility with HE
• Destroy/Degrade on-orbit facility with a Projectile
• Destroy/Degrade on-orbit facility with a nuclear weapon
• Destroy/Degrade satellite with HE
• Destroy/Degrade satellite with Projectile
• Destroy/Degrade satellite with nuclear weapons
• Destroy/Degrade space-based link segment with HE
• Destroy/Degrade space-based link segment with Projectile
• Destroy/Degrade space sensors with HE
• Destroy/Degrade space sensors with Projectile
• Destroy/Degrade space transport vehicles with HE
• Destroy/Degrade space transport vehicles with Projectile
• Destroy/Degrade space transport vehicles with nuclear weapons
• Destroy/Degrade ground-launched (launch platform or missile) ASAT with a Projectile
• Destroy/Degrade ground-launched (launch platform or missile) ASAT with HE
• Destroy/Degrade a ground-launched ASAT (launch platform or missile) with nuclear weapons
• Destroy/Degrade space-launched ASAT with a Projectile
• Destroy/Degrade space-launched ASAT with HE
• Destroy/Degrade space-launched ASAT with a nuclear weapon
• Destroy/Degrade inspectors with HE
• Destroy/Degrade inspectors with a Projectile
• Deny/Disrupt inspectors with EW Jamming
• Deceive inspectors with EW Deception
• Destroy/Degrade space-to-space weapons platforms with HE
• Destroy/Degrade space-to-space weapons platforms with nuclear weapon from the ground
• Destroy/Degrade space-to-ground weapons and weapons platforms with HE

Engagement – Cont.

Defeat Space Target Be Ahead
• Destroy/Degrade on-orbit facility with Directional, Non-nuclear EMP
• Destroy/Degrade satellite with Directional, Non-nuclear EMP
• Destroy/Degrade space-based link segment with Directional, Non-nuclear EMP
• Deny/Disrupt space-based link segment with EW Jamming
• Deceive space-based link segment with EW Deception
• Destroy/Degrade space sensors with Directional, non-nuclear EMP
• Deny/Disrupt space sensors with EW Jamming
• Deny/Disrupt space sensors with EW Deception
• Destroy/Degrade space transport vehicles with Directional, Non-nuclear EMP
• Deny/Disrupt space transport vehicles with EW Jamming
• Deny/Disrupt space transport vehicles with EW Deception
• Destroy/Degrade ground-launched ASAT C2/TT&C equipment with Directional, Non-nuclear EMP
• Destroy/Degrade space-launched ASAT with Directional, Non-nuclear EMP
• Deny/Disrupt ASAT C2/TT&C with EW Jamming
• Deceive ASAT C2/TT&C with EW Deception
• Destroy/Degrade inspectors with Directional, Non-nuclear EMP
• Destroy/Degrade space-to-space weapons platforms with Directional, Non-nuclear EMP
• Deny/Disrupt space-to-space weapons platforms with EW Jamming
• Deceive space-to-space weapons platforms with EW Deception
• Destroy/Degrade space-to-ground weapons and weapons platforms with Directional, Non-nuclear EMP
• Deny/Disrupt space-to-ground weapons and weapons platforms with EW Jamming
• Deceive space-to-ground weapons and weapons platforms with EW Deception

Engagement – Cont.

Defeat Space Target Be Way Ahead
• Destroy/Degrade/Deny on-orbit facility with DE
• Deny on-orbit facility with Computer Network Attack
• Disrupt on-orbit facility with Computer Network Attack
• Deceive on-orbit facility with Computer Network Attack
• Hijack on-orbit facility with Computer Network Attack
• Destroy/Degrade/Deny satellite with DE
• Deny satellite with Computer Network Attack
• Disrupt satellite with Computer Network Attack
• Deceive satellite with Computer Network Attack
• Hijack satellite with Computer Network Attack
• Destroy/Degrade/Deny space-based link segment with DE
• Deny space-based link segment with Computer Network Attack
• Disrupt space-based link segment with Computer Network Attack
• Deceive space-based link segment with Computer Network Attack
• Hijack space-based link segment with Computer Network Attack
• Destroy/Degrade/Deny space sensors with DE
• Destroy/Degrade/Deny space sensors with obscurant (mist or foam)
• Deny space sensors with Computer Network Attack
• Disrupt space sensors with Computer Network Attack
• Deceive space sensors with Computer Network Attack
• Destroy/Degrade/Deny space transport vehicles with DE
• Deny space transport vehicles with Computer Network Attack
• Disrupt space transport vehicles with Computer Network Attack
• Deceive space transport vehicles with Computer Network Attack
• Hijack space transport vehicles with Computer Network Attack
• Destroy/Degrade with ground-launched ASAT (launch platform or missile) with DE
• Destroy/Degrade space-launched ASAT with DE
• Deny ASAT C2/TT&C with Computer Network Attack
• Disrupt ASAT C2/TT&C with Computer Network Attack
• Deceive ASAT C2/TT&C with Computer Network Attack
• Destroy/Degrade/Deny inspectors with DE
• Deny inspectors with Computer Network Attack
• Disrupt inspectors with Computer Network Attack

Engagement – Cont.

Defeat Space Target Be Way Ahead
• Deceive inspectors with Computer Network Attack
• Hijack inspectors with Computer Network Attack
• Destroy/Degrade/Deny space-to-space weapons platforms with DE
• Deny space-to-space weapons platforms with Computer Network Attack
• Disrupt space-to-space weapons platforms with Computer Network Attack
• Deceive space-to-space weapons platforms with Computer Network Attack
• Destroy/Degrade/Deny space-to-ground weapons and weapons platforms with DE
• Deny space-to-ground weapons platforms with Computer Network Attack
• Disrupt space-to-ground weapons platforms with Computer Network Attack
• Deceive space-to-ground weapons platforms with Computer Network Attack
• Hijack space-to-ground weapons platforms with Computer Network Attack

Engagement – Cont.

Defeat a Cyber Target Neutral
• Destroy/Degrade desktop/laptop computer with HE
• Destroy/Degrade mainframe computer with HE
• Destroy/Degrade biometric security systems with HE

Defeat a Cyber Target Equal
• Destroy/Degrade above-ground wired (landline) communications network links with HE
• Destroy/Degrade below-ground and deeply buried wired (landline) communications network links with HE
• Destroy/Degrade communications network nodes (wireless or wireline routers, hubs) with HE
• Destroy/Degrade communications network nodes (wireless or wireline routers, hubs) with a Projectile
• Destroy/Degrade wireline or wireless server box with HE

Engagement – Cont.

Defeat a Cyber Target Be Ahead
• Destroy/Degrade above-ground wired (landline) communications network links with Directional, Non-nuclear EMP
• Deny/Disrupt above-ground wired (landline) communications network links with EW Jamming
• Destroy/Degrade below-ground and deeply buried wired (landline) communications network links with Directional, Non-nuclear EMP
• Deny/Disrupt wireless communications network links with EW Jamming
• Destroy/Degrade communications nodes (wireless or wireline routers, hubs) with Directional, Non-nuclear EMP
• Deny/Disrupt wireless communications network nodes (routers, hubs) with EW Jamming
• Destroy/Degrade wireline or wireless server box with Directional, Non-nuclear EMP
• Destroy/Degrade desktop/laptop computer with Directional, Non-nuclear EMP
• Deny/Disrupt desktop/laptop computer with EW Jamming
• Destroy/Degrade mainframe computer with Directional, Non-nuclear EMP
• Deny/Disrupt mainframe computer with EW Jamming
• Destroy/Degrade biometric security systems with Directional, Non-nuclear EMP
• Destroy/Degrade/Deny/Disrupt/Deceive biometric security systems with Electronic Jamming
• Deny/Disrupt biometric security systems with EW Jamming

Engagement – Cont.

Defeat a Cyber Target Be Way Ahead
• Destroy/Degrade/Deny above-ground wired (landline) communications network links with DE
• Destroy/Degrade/Deny above-ground wired (landline) communications network links with grounding weapons
• Destroy/Degrade/Deny above-ground wired (landline) communications network links with magnetic weapons
• Deceive wireless communications network links with EW Deception
• Deny wireless communications network links with Computer Network Attack
• Disrupt wireless communications network links with Computer Network Attack
• Deceive wireless communications network links with Computer Network Attack
• Hijack wireless communications network links with Computer Network Attack
• Deny wireless computer-to-computer network links with Computer Network Attack
• Disrupt wireless computer-to-computer network links with Computer Network Attack
• Deceive wireless computer-to-computer network links with Computer Network Attack
• Destroy/Degrade communications network nodes (wireless or wireline routers, hubs) with DE
• Destroy/Degrade communications network nodes (wireless or wireline routers, hubs) with Chipping
• Deceive wireless communications network nodes (routers, hubs) with EW Deception
• Deny wireless communications network nodes (routers, hubs) with Computer Network Attack
• Disrupt wireless communications network nodes (routers, hubs) with Computer Network Attack
• Deceive wireless communications network nodes (routers, hubs) with Computer Network Attack
• Hijack wireless communications network nodes (routers, hubs) with Computer Network Attack
• Destroy/Degrade wireline or wireless server box with DE
• Deceive wireless server with EW Deception
• Deny wireless server with Computer Network Attack
• Disrupt wireless server with Computer Network Attack
• Deceive wireless server with Computer Network Attack

Engagement – Cont.

Defeat a Cyber Target Be Way Ahead – Cont.
• Hijack wireless server with Computer Network Attack
• Deceive wireline server with EW Deception
• Deny wireline server with Computer Network Attack
• Disrupt wireline server with Computer Network Attack
• Deceive wireline server with Computer Network Attack
• Hijack wireline server with Computer Network Attack
• Destroy/Degrade desktop/laptop computer with DE
• Destroy/Degrade desktop/laptop computer with Chipping
• Deceive desktop/laptop computer with EW Deception
• Deny desktop/laptop computer with Computer Network Attack
• Disrupt desktop/laptop computer with Computer Network Attack
• Deceive desktop/laptop computer with Computer Network Attack
• Hijack desktop/laptop computer with Computer Network Attack
• Destroy/Degrade mainframe computer with DE
• Destroy/Degrade mainframe computer with Chipping
• Deceive mainframe computer with EW Deception
• Deny mainframe computer with Computer Network Attack
• Disrupt mainframe computer with Computer Network Attack
• Deceive mainframe computer with Computer Network Attack
• Hijack mainframe computer with Computer Network Attack
• Deny cyber sensors with Computer Network Attack
• Disrupt cyber sensors with Computer Network Attack
• Deceive cyber sensors with Computer Network Attack
• Hijack cyber sensors with Computer Network Attack
• Deny/Disrupt/Deceive access to a website
• Hijack a website link
• Hijack cyber sensors with Computer Network Attack
• Deny network applications (e-mail, web browsers, etc.) with Computer Network Attack.
• Disrupt network applications (e-mail, web browsers, etc.) with Computer Network Attack.
• Deceive network applications (e-mail, web browsers, etc.) with Computer Network Attack.
• Hijack network applications (e-mail, web browsers, etc.) with Computer Network Attack.

Engagement – Cont.

Defeat a Cyber Target Be Way Ahead – Cont.
• Deny local machine applications (analysis tools, word processors, etc.) with Computer Network Attack
• Disrupt local machine applications (analysis tools, word processors, etc.) with Computer Network Attack
• Deceive local machine applications (analysis tools, word processors, etc.) with Computer Network Attack
• Deny a firewall with Computer Network Attack
• Disrupt a firewall with Computer Network Attack
• Deceive a firewall with Computer Network Attack
• Hijack a firewall with Computer Network Attack
• Deny an encryption system with Computer Network Attack
• Disrupt an encryption system with Computer Network Attack
• Deceive an encryption system with Computer Network Attack
• Hijack an encryption system with Computer Network Attack
• Deny an MLS system with Computer Network Attack
• Disrupt an MLS system with Computer Network Attack
• Deceive an MLS system with Computer Network Attack
• Hijack an MLS system with Computer Network Attack
• Destroy/Degrade biometric security systems with DE
• Deny biometric security systems with Computer Network Attack
• Disrupt biometric security systems with Computer Network Attack
• Deceive biometric security systems with Computer Network Attack
• Hijack biometric security systems with Computer Network Attack
• Deceive biometric security systems with biometric replication technology
• Deny a database with Computer Network Attack
• Disrupt a database with Computer Network Attack
• Deceive a database with Computer Network Attack
• Hijack a database with Computer Network Attack
• Deny a data object with Computer Network Attack
• Disrupt a data object with Computer Network Attack
• Deceive a data object with Computer Network Attack
• Hijack a data object with Computer Network Attack

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Appendix B

Critical Technologies for Force Application Organized by Broad Industrial Areas

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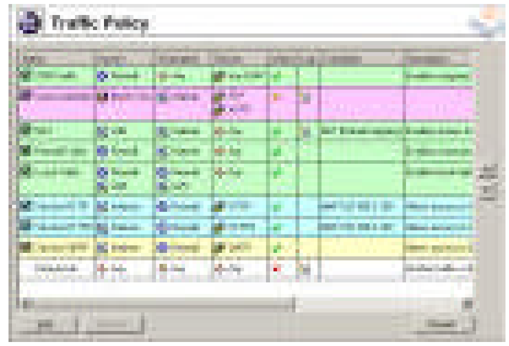
Acoustic Energy Weapons

A host of military missions are being considered for acoustic weapons, including both battlefield combat and operations other than war—urban combat, crowd control, hostage rescue, perimeter defense, and physical security. They may also be capable of damaging or destroying underwater sensors, even submersed vehicle structures.

- Acoustic Beam Steering and Focusing Device
- Acoustic Grenade
- Directed Acoustics via Ultrasonic Heterodyne
- Hydraulic Supercavitation Device (Electro-Hydraulic Cavitation)
- Phased Array Acoustic Device
- Sonic Fire Hose

Computer Network Attack (CNA)

Computer network attack (CNA) can be accomplished a number of ways, two of the more common methods are mobile codes and computer logic bomb. Mobile codes are typically automatically downloaded into user's workstations and executed without the user's initiation or knowledge. Where as a computer logic bomb is programming code added surreptitiously or intentionally to the software of an application or operating system that lies dormant until a predetermined period of time or event occurs, triggering execution of the code—a Trojan house.



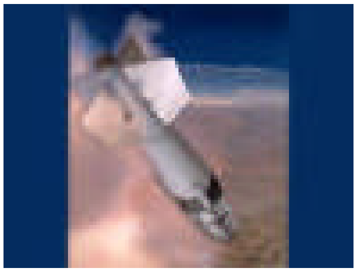
- Biometric Replication Technology
- Chipped CPU
- Chipped Integrated Circuit
- Chipped Memory Chip
- Computer Logic Bomb
- Denial-of-Service Software
- Domain Name Server Corruption Software
- Executable Load Virus
- Macro/Visual Basic Virus
- Mobile Code
- Packet Fragmentation Device
- Packet Sequence Attack Device
- Packet Sniffing Software
- Password Cracking Software
- Pre-Programmed Wireless Access Point
- Spoofing Software
- Stealth Virus
- Trojan Horse
- Wireless/Wireline Routing & Addressing Penetration
- Worm
- Zombie

Devices	
Devices encompass hardware which provides critical functionality to a weapon or support system. These include recovery systems for personnel and UAVs to catapults and deployable bridges.	

- Advanced Net Recovery Material
- Autonomous Parachute Deployment Device
- Autonomous Parachute Recovery Device
- Broaching Canister
- Broaching Universal Buoyant Launcher
- Common Automated UAV/UCAV Recovery System
- Electromagnetic Catapults
- Floating Deployable Landing Pad
- Inflatable/Fabric Roadway
- Internal Carry Munitions Launcher
- Low-Price Stealthy Capsule
- Low-Shock, Non-Pyrotechnic Release Mechanism
- Multiple All-Around Canister (MAC)
- Multiple-Tubed, Neutrally Buoyant Canister
- Rapidly Deployable Bridge
- Self-Stabilizing Crane
- Small Munitions Dispenser
- Space Obscurant Dispenser
- Submarine Bomb-Bay-Type Doors
- Underwater Pneumatic Ejection
- Universal Canister
- Weapons Pylon
- Wind-Corrected Munitions Dispenser

Explosive Weapons

Explosive weapons include the typical class of weaponry one would expect to find under force Application: warheads for missiles, fragmentation warheads, bomblets, artillery munitions, shaped-charged warheads, mines, and torpedoes. It also includes concepts such as reactive materials and nano technology devices. This industrial area includes all technologies that provide desired weapons effects that damage or destroy targets.



- Air-to-Air Missile Warhead
- Chemically Reactive Fragmentation Warhead
- Dialable Effects Warhead
- Explosively Driven Electro-Hydraulic Cavitation Device (“Water Hammer”)
- Fuel-Air Explosive Bomblet
- GPS-Guided Small Diameter Bomb (SDB)
- Guided Artillery Munition
- High-Energy Density Material (HEDM) Weapons
- Massive Ordinance Air Burst (MOAB)
- MEMS-Based Smart Artillery Munition
- Metal Augmented Charge Warhead for Sustained Pressure Effects
- Miniature Explosive Device
- Pilot-Hole Conventional Weapon System
- Shaped-Charged Warhead
- Small-Blast-Area Weapon
- Stealthy Torpedo
- Supercavitating Torpedo
- Torpedo Mine

Guns/Cannons

This industrial area contains the classical weapons of war—guns and cannons. In the future, this area will see the inclusion of new families of weapons such as railgun technologies and electronically fired weapons—Metal Storm.

- Electromagnetic Railgun
- Million-Rounds-Per-Minute Gun (Metal Storm)
- Next-Generation Infantry Weapon
- Next-Generation Long-Range Sniper Rifle

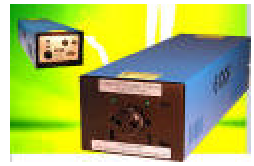
Kinetic Energy Weapons

Limitations of the capabilities of current penetrating weapons have led researchers to consider hypervelocity kinetic weapons. These projectiles could reach velocities of 20 to 30 thousand feet per second. A subsection of this research encompasses control technology for this class of weapon.

- Advanced Armor-Penetrating Sabot Tank Munition
- Hypervelocity Rod
- Railgun Projectiles
- Smart Bullets
- Terminally Guided Submunition Penetrator

Optical Energy Weapons

The optical energy weapons area includes not only laser weapons technology but the system level controls and beam shaping technologies which make these systems effective weapons. In an optical energy weapon system, the continuously adjustment of the mirror system is needed to control the optical energy weapon beam.

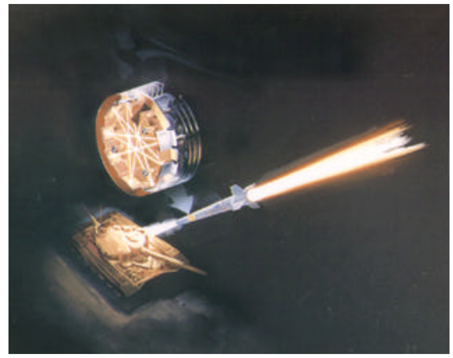


- Adaptive Laser Optics
- Chemical Oxygen Iodine Laser (COIL)
- Deuterium Fluoride Laser
- Diode-Pumped, Solid-State Laser
- Electrically Driven, Solid-State, High-Energy Laser
- Excimer Laser
- High-Energy Laser Beam Control Device
- High-Power Carbon Dioxide Laser
- Hydrogen Fluoride Laser
- Laser Calibrator
- Laser Diagnostics Device
- Small, Tactical Optical Munition
- Thin-Film, Space-Erectable Mirror

Propulsion

The propulsion industrial area is very board. It contains technologies for manned-rate, air-breathing propulsion systems to solid rocket motor technology for missiles. These propulsion systems power our aircraft, ships, weapons, and even our unmanned platforms. They are capable of moving our weapons systems at a few knots through the water or accelerate a vehicle to velocities that would allow flight to low earth orbit.

- Advanced Air-to-Air Missile Propulsion
- Advanced Air-to-Ground Missile Propulsion System
- Advanced Supersonic Strike Weapon Propulsion
- Advanced Turbofan Engine
- Band Tracked System
- Cushion Propulsion
- Electromagnetic/Pulsed-Plasma Thruster
- Fast-Tracked System
- Four-Bladed Rotor
- Gas-Turbine Engine
- Hybrid Missile/Rocket Propellant
- Hybrid-Electric Drive
- Hypersonic Platform Engine
- Hypersonic Weapon Propulsion System
- Legged Machine Propulsion System
- Lightweight, All-Fuel Engine
- Maritime Electric Propulsion
- Mine Propulsion for Self-Repairing Mine Fields
- Miniaturized UAV Turbine Engine
- Multi-Legged UGVs Propulsion System
- Pulse Detonation Engine
- Rear-Rotor Propulsion System
- Scramjet
- Small Advanced Turbine Engine
- Solar Thermal Propulsion System
- Super-Cavitation System
- Supercruise-Capable Engine
- Sustainer Motor
- Thrust Vectoring Nozzle
- Tilt Rotor

RF Energy Weapons	
Electronic warfare comprises three major subdivisions: Electronic attack—use of electromagnetic or directed energy to attack personnel, facilities, or equipment with the intent of degrading, neutralizing, or destroying enemy capabilities; Electronic Support—actions taken to search for, intercept, identify, and locate sources of radiated electromagnetic energy; and Electronic Protection—actions taken to protect personnel, facilities, or equipment. The RF Energy Weapons industrial area deals with Electronic Attack. The objective of the capabilities produced in this are to degrade, damage, or destroy enemy capabilities using electromagnetic weapons.	

- Barrage Jammer
- ECM/Jammer Deception Device
- Frequency-Hopping Jammer
- Gigawatt S-Band Frequency-Tunable HPM Device
- High-Efficiency Virtual Cathode Oscillator (Vircator) HPM Device
- HPM Flux Compression Generator
- Millimeter-Wave Emission Device
- Modified Cell Blocker
- Narrowband Pulse Power Device
- Non-Nuclear EMP Weapon
- Phased Array Microwave System (PAMS)
- Self-Filamentation-in-Air (Artificial Lightning) Device
- Suitcase-Sized, High-Powered Electromagnetic Pulse (EMP) Device
- Tactical Noise Jammer
- Time Division Multiplex Jammer
- Ultra-Wideband Pulse Power HPM Device
- Wireless Jamming Device

Special Purpose Weapons	
Special purpose weapons are predominately made up of non-lethal technologies. This class of weapons will continue to be of interest as military operation other than war increases.	

- Anti-Traction Compound
- Carbon Fiber Weapon
- Entangler Device
- Hologram Generating Device
- Incapacitant Gas
- Jellied Super Acid
- Long-Range, Laser-Light, Text-Messaging Projection
- Long-Range, Multi-Dimensional Broadcast System
- Low-Level Combustible Dispersant
- Material Embrittlement Corrosive
- Metal- Chewing Microbes
- Obscurant
- Odor/Nausea-Inducing Weapon
- Polymer Interferant
- Self-Propagating High-Temperature Synthesis (SHS) Device
- Skin Irritant
- Sticky Foam
- Stun Device
- Stun Grenade

Structures

This industrial area is made up of the traditional material and structures technology which form the backbone of our weapons platforms. Advanced material and structure will continue to be capability enablers.

BALLUTE BOMB (USAF)

- 360-Degree Rotatable Wheel Arm
- Adaptive Wing Structure
- Advanced High-Stress-Tolerant Airframe/Missile Material
- Advanced Submersible High-Pressure/Stress-Tolerant Materials
- Advanced Surface Ship Hull Materials
- Advanced Vehicle Stabilization System
- Alloy-Based, Airframe/Missile Materials
- Artificial Tendons (Air Cushion Skirt)
- Autonomous Refueling/Replenishment System
- Autonomous Weight Distribution System
- Backward-Canted Bow Design
- Blended Wing Body
- Canard, Pop-Out Fins
- Forward-Swept Wings
- Gliding Airframe
- Heavy Weapons Robot (Hwbot) Structure
- High Lift-to-Drag Ratio Airframe
- High Performance Control Surfaces/Thrusters
- Hypersonic Transatmospheric Vehicle, High-Stress-Tolerant Structural Materials
- In-Flight Refueling Equipment
- Inward-Angled "Tumblehome" Hull
- Lightweight Chassis
- Low-Profile Turret
- Mine Maneuvering Arm
- Mine Maneuvering Leg
- Modular Munition Casing for Multi-Purpose Load-Out
- Movable Tail Wing
- Multi-Functional Structure
- Propulsion/Airframe Integrated Structure
- Rugged Landing Gear
- Single-Chassis, Adaptable Vehicle
- Small, Pop-Out Tail Fins
- Small-Caliber Projectile Control Surfaces
- Spider UGV Structure
- Ultra-High-Temperature Materials
- Variable-Geometry Wing
- Weapon Atmospheric Reentry Vehicle Assembly

Weapons Fuses	
The operational effects of many weapons is based upon the weapon's fusing mechanism. The capability to detonate upon impact or to penetrate the target and then detonate is based in large part on the fuse used to initiate the detonation sequence. This industrial area will continue to demand innovative mechanism to meet warfighter needs.	
♦ Fuel-Air Explosive Fuse ♦ Impact Detonating Fuse ♦ Prerelease Selectable Penetration Weapon Fuse ♦ Proximity Fuse ♦ Void Detection Fuse	

Weapons Guidance and Control

This technology area is made up of a multitude of technologies used to guide a weapon to its point of impact or control the flight of the weapon to its target. Laser, GPS, radar, and the associate guidance systems are examples of the class of technologies being considered in this industrial are.

- Acoustic Guidance System
- Acquisition, Tracking, and Pointing Laser
- Aiming/Lock-On Laser
- Beacon Illuminator Laser
- GPS-Guided Munition Guidance System
- Heat-Seeking Air-to-Air Missile Guidance System
- Jitter and Vibration Management System
- Laser Guided Munition Guidance and Control System
- Micro-Laser Guidance for Small Projectiles
- Optical Sight
- Post-Boost Vehicle Control System (PBVCS)
- Radar-Guided Air-to-Air Missile Guidance and Control System
- Self-Guided Munition Guidance System
- Terrain-Aided Guidance and Control Device

APPENDIX C

A COMPENDIUM OF REPRESENTATIVE DEFENSE TECHNOLOGY SUPPLIERS WITH TRANSFORMATIONAL CAPABILITIES

NOTE: Companies listed are representative; the list is not exhaustive. Inclusion or exclusion does not imply future business opportunities with or endorsement by DoD.

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Acoustic Energy Weapons: Electro-Hydraulic Cavitation Device						
Tetra Corporation	1977	Albuquerque, NM	2	N/A	www.tetra-corporation.com	Electrohydraulic and pulsed power technologies for the mining and rock crushing industry
Devices: Common Automated UAV/UCAV Recovery System						
Advanced Technologies & Engineering (ATE) Co. (PTY) Ltd	2004	Halfway House, South Africa	N/A	N/A	www.ate-aerospace.com	Development, production and logistic support of VULTURE UAV system specifically designed for automated launch, flight and recovery
BAI Aerosystems	1985	Easton, MD	155	$12.3	www.baiaerosystems.com	UAVs and support equipment
China National Aero Technology Import and Export Corporation (CATIC)	1979	Beijing, China	2,000	$912.7	web.catic.com.cn	Import and export of aviation products
Insitu Group	1994	Bingen, WA	30	$1.8	www.insitugroup.net	Aviation and aeronautical engineering
QinetiQ	2001	Hampshire, U.K.	88,898	$1,414.8	www.QinetiQ.com	Private/public provider of research and engineering services for the UK
Sierra Nevada Corporation (SNC)	1963	Sparks, NV	500	$153.9	www.sncorp.com	UAV automatic launch and recovery systems
Explosive Weapons: Dialable Effects Warhead						
Lockheed Martin	1909	Orlando, FL	70	$4.1	www.missilesandfirecontrol.com	Manufacturer of the Low Cost Autonomous Attack System (LOCAAS) smart submunition
Raytheon Missile Systems	1997	Tucson, AZ	11,000	$1,132.5	www.raytheon.com	Designs and manufactures weapons systems and sensors
US Army Picatinny Arsenal	1977	Picatinny, NJ	159	N/A	w4.pica.army.mil	Army's principal researcher, developer and sustainer of current and future armament and munitions systems
Explosive Weapons: Dialable Effects Warhead – Adjustable Fusing						
ATK Ordnance	1990	Plymouth, MN	12,000	$2,366.2	www.atk.com	Ordnance reclamation for aerospace and defense systems
BT Fuze Products	2001	Lancaster, PA	250	$9.2	www-btfuze.tw.l-3com.com	Radio and TV communications equipment
KDI Precision Products, Inc.	1998	Cincinnati, OH	240	$57.3	www.kdi-ppi.com	Arming and fusing devices for missiles and artillery
Motorola Israel, Ltd.	1986	Tel Aviv, Israel	440	$300.2	www.israel.motorola.com	Radio and TV communications equipment
TDA Armaments	1994	La Ferte Saint Aubin, France	500	$96.6	www.tda-arm.fr	Military armored vehicle, tank, and tank component manufacturing
Thales Missile Electronics, Ltd.	1968	Basingstoke, U.K.	356	$41.6	www.thalesgroup.com/airbornesystems	Fuses and electronic components
Explosive Weapons: GPS-Guided, Small-Diameter Bomb (SDB)						
The Boeing Company	1916	St. Louis, MO	175	$11.8	www.boeing.com	Aircraft manufacturing
KDI Precision Products division of L3 Communications	1998	Cincinnati, OH	240	$57.3	www.kdi-ppi.com	Manufacture arming and fusing devices for missiles and artillery
Rockwell Collins	2003	Cedar Rapids, IA	14,950	$2,542.0	www.rockwellcollins.com	Search/navigation, radio, and TV communication equipment
Sargent Fletcher Inc.,	1940	El Monte, CA	N/A	N/A	www.sargentfletcher.com	Manufacture probe and drogue aerial refueling systems, special purpose pods, and external fuel tanks
SRI International	1946	Menlo Park, CA	1,400	$220.0	www.sri.com	Independent, nonprofit research institute
Explosive Weapons: GPS-Guided, Small-Diameter Bomb (SDB) – High-Performance Explosive						
Aerojet	1944	Sacramento, CA	2,700	$1,192.0	www.aerojet.com	Ammunition components
EURENCO	1971	Paris, France	2,240	$118.8	www.eurenco.com	Explosives manufacturing

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Explosive Weapons: GPS-Guided, Small-Diameter Bomb (SDB) – Penetration Casing						
Ellwood National Forge	2003	Ellwood City, PA	125	$30.0	www.elwd.com	Machining
General Dynamics Ordinancy and Tactical Systems (OTS)	1938	Garland, TX	617	$38.6	www.imco-usa.com	Manufacturing missile and space vehicle components manufacturing aluminum forgings
Explosive Weapons: High Energy Density Material (HEDM) Weapon						
AFRL Munitions Directorate, Ordnance Division, Energetic Materials Branch	1966	Eglin AFB, FL	N/A	N/A	www.afrl.af.mil	Explosive research, development, test and evaluation (RDT&E) capability and quick reaction explosives loading
Lawrence Livermore National LaB	1952	Livermore, CA	8,000	$632.9	www.llnl.gov	Energy research
QinetiQ Nanomaterials	2001	Farnborough, U.K	88,898	$1,414.8	www.QinetiQ.com	Private/public provider of research and engineering services for the UK
U.S. Army Armament Research, Development and Engineering Center (ARDEC)	1977	Picatinny, NJ	159	N/A	w4.pica.army.mil	Army's principal researcher, developer and sustainer of current and future armament and munitions systems
Guns/Cannons: Electromagnetic Railgun						
BAE Systems – Controls	2000	Johnson City, NY	1,850	$369.0	www.baesystemscontrols.com	Aircraft/aerospace flight instruments and guidance systems
IAP Research, Inc.	1981	Dayton, OH	20	$3.8	www.iap.com	Government/commercial physical research
Institut Saint-Louis (ISL)	1959	Saint-Louis, France	410	N/A	www.isl.tm.fr	Colleges and universities
Kaman Aerospace	1945	Bloomfield, CT	1,326	$111.7	www.kamanaero.com	Advanced electro-optic systems for defense applications
Lockheed Martin Missiles and Fire Control	1909	Bethesda, MD	130,000	$31,824.0	www.lockheedmartin.com	Design manufacture and integration of advanced technology products and services for the US government and private industry
QinetiQ, Electromagnetics Weapons Division	2001	Hampshire, U.K.	88,898	$1,414.8	www.QinetiQ.com	A private/public provider of research and engineering services for the UK
Science Applications International Corporation (SAIC)	1969	San Diego, CA	44,000	$6,700.0	www.saic.com/	Largest employee-owned research and engineering firm
Silicon Power Corporation	1994	Malvern, PA	100	$9.6	www.siliconpower.com	Power semi-conductor components
Titan Systems Corporation	2000	Annapolis Junction, MD	168	$16.6	www.titan.com	Design and assembly of electro mechanical communications systems and provides engineering consulting services
University of Texas Institute for Advanced Technology (IAT)	1990	Austin, TX	N/A	N/A	www.iat.utexas.edu	Basic and applied research in electrodynamics, hypervelocity physics, pulsed power, and education in related critical technologies
Guns/Cannons: Million Rounds-per-Minute Gun (Metal Storm)						
Metal Storm, Ltd.	1994	Brisbane, Australia	9	$1.0	www.metalstorm.com	Electronic ballistics system

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Sources: SEC Filings, Orbis Bureau van Dijk databases, RDS Business and Industry database, LexisNexis Academic Universe, S&P reports, Hoover's, US Major Companies Database, Yahoo Finance, US Business Directory, Dun & Bradstreet, and First Equity research.

Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Kinetic Energy Weapons: Railgun Projectiles						
BAE Systems – Controls	2000	Johnson City, NY	1,850	$369.0	www.baesystemscontrols.com	Aircraft/aerospace flight instruments and guidance systems
IAP Research, Inc.	1981	Dayton, OH	20	$3.8	www.iap.com	Government/commercial physical research
Institut Saint-Louis (ISL)	1959	Saint-Louis, France	410	N/A	www.isl.tm.fr	Colleges and universities
Kaman Aerospace	1945	Bloomfield, CT	1,326	$111.7	www.kamanaero.com	Advanced electro-optic systems for defense applications
Lockheed Martin Missiles and Fire Control	1909	Bethesda, MD	130,000	$31,824.0	www.lockheedmartin.com	Design manufacture and integration of advanced technology products and services for the US government and private industry
QinetiQ, Electromagnetics Weapons Division	2001	Hampshire, U.K.	88,898	$1,414.8	www.QinetiQ.com	Private/public provider of research and engineering services for the UK
Science Applications International Corporation (SAIC)	1969	San Diego, CA	44,000	$6,700.0	www.saic.com/	Largest employee-owned research and engineering firm
Silicon Power Corporation	1994	Malvern, PA	100	$9.6	www.siliconpower.com	Power semi-conductor components
Titan Systems Corporation	2000	Annapolis Junction, MD	168	$16.6	www.titan.com	Design and assembly of electro mechanical communications systems and provides engineering consulting services
University of Texas Institute for Advanced Technology (IAT)	1990	Austin, TX	N/A	N/A	www.iat.utexas.edu	Basic and applied research in electrodynamics, hypervelocity physics, pulsed power, and education in related critical technologies
Optical Energy Weapons: Adaptive Laser Optics						
AOptix	2000	Campbell, CA	25	$1.0	www.aoptix.com	Develop and manufacture laser communication equipment
CILAS	1966	Marcoussis, France	237	$24.6	www.cilas.com	Search and navigation equipment
OKO Technologies	N/A	Delft, The Netherlands	N/A	N/A	www.okotech.com	Manufacturer of MEMS deformable mirrors and adaptive optical systems
ONERA	1946	Paris, France	2,012	$266.8	www.onera.fr	French aeronautics and research center
Trex Enterprises	2000	San Diego, CA	150	$29.0	www.trexenterprises.com	Contract research and technology development services
Xinetics, Inc.	1994	Littleton, MA	53	$8.7	www.xinetics.com	Optical instruments and lenses
Optical Energy Weapons: Adaptive Laser Optics – Deformable Mirrors						
AOptix	2000	Campbell, CA	25	$1.0	www.aoptix.com	Develop and manufacture laser communication equipment
CILAS	1966	Marcoussis, France	237	$24.6	www.cilas.com	Search and navigation equipment
OKO Technologies	N/A	Delft, The Netherlands	N/A	N/A	www.okotech.com	N/A
ONERA	1946	Paris, France	2,012	$266.8	www.onera.fr	French aeronautics and research center
Trex Enterprises	2000	San Diego, CA	150	$29.0	www.trexenterprises.com	Contract research and technology development services
Xinetics, Inc.	1994	Littleton, MA	53	$8.7	www.xinetics.com	Optical instruments and lenses

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Optical Energy Weapons: Adaptive Laser Optics – Wavefront Sensor						
Adaptive Optics Associates, Inc. (AOA)	2001	Cambridge, MA	110	$22.0	www.aoainc.com	Optical instrument and lens manufacturing
AOptix	2000	Campbell, CA	25	$1.0	www.aoptix.com	Develop and manufacture laser communication equipment
Arden Photonics Ltd.	2001	Solihull, U.K.	N/A	N/A	www.ardenphotonics.com	Developing, manufacturing and selling innovative products for the photonics industry
ONERA	1946	Paris, France	2,012	$266.8	www.onera.fr	French aeronautics and research center
Spot-Optics.com	1977	Padova, Italy	N/A	N/A	www.spot-optics.com	Shack-Hartmann wavefront sensors
Trex Enterprises	2000	San Diego, CA	150	$29.0	www.trexenterprises.com	Contract research and technology development services
Optical Energy Weapons: Chemical Oxygen Iodine Laser (COIL)						
Northrop Grumman	1930	Los Angeles, CA	122,600	$26,206.0	www.northropgrumman.com	Search and detection systems and instruments
The Boeing Company	1934	Chicago, IL	166,070	$50,485.0	www.boeing.com	Manufacture commercial and military aircraft and defense electronics
Optical Energy Weapons: Chemical Oxygen Iodine Laser (COIL) – Laser Cavity						
Baltic State Technical University	1930	St. Petersburg, Russia	N/A	N/A	www.informika.ru	Developed a 10-kW class COIL experiment
Ben-Gurion University (BGU)	1964	Negev, Israel	3,500	$273.7	www.bgu.ac.il	Colleges and universities
Czech Academy of Science	1992	Prague, The Czech Republic	6,300	N/A	www.cas.cz	Research and experiments using a chemically driven iodine atom delivery system on the COIL laser
Northrop Grumman	1930	Los Angeles, CA	122,600	$26,206.0	www.northropgrumman.com	Search and detection systems and instruments
The Boeing Company	1916	Chicago, IL	166,070	$50,485.0	www.boeing.com	Manufacture commercial and military aircraft and defense electronics
Optical Energy Weapons: Chemical Oxygen Iodine Laser (COIL) – Supersonic Nozzle						
Baltic State Technical University	1930	St. Petersburg, Russia	N/A	N/A	www.informika.ru	Achieved a record 33% efficiency level with a COIL laser that uses a nitrogen (previously used helium) dilutents
Ben-Gurion University (BGU)	1964	Negev, Israel	3,500	$273.7	www.bgu.ac.il	Colleges and universities
CU Aerospace	1998	Champaign, IL	7	N/A	www.cuaerospace.com	Partially electrically excited laser(ElectriCOIL)
Kawasaki Heavy Industries	1896	Kobe, Japan	29,651	$7,694.5	www.khi.co.jp	Motorcycles, bicycles and parts
STI Optronics, Inc.	1993	Bellevue, WA	63	$6.0	www.stioptronics.com	Commercial research laboratory
The Boeing Company	1916	Chicago, IL	166,070	$50,485.0	www.boeing.com	Manufacture commercial and military aircraft and defense electronics

[1] **Companies listed are representative; the list is not exhaustive. Inclusion or exclusion does not imply future business opportunities with or endorsement by DoD.**

Sources: SEC Filings, Orbis Bureau van Dijk databases, RDS Business and Industry database, LexisNexis Academic Universe, S&P reports, Hoover's, US Major Companies Database, Yahoo Finance, US Business Directory, Dun & Bradstreet, and First Equity research.

Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Optical Energy Weapons: Electrically Driven, Solid-State, High-Energy Laser						
BAE Systems	1977	Bristol, United Kingdom	68,400	$14,911.2	www.baesystems.com	Systems integration, complex software and hardware development and advanced manufacturing of military aircraft, surface ships, submarines, space systems, radar, avionics, C4ISR, electronic systems, guided weapons and a range of other defense products
HRL Laboratories	2000	Malibu, CA	340	$80.0	www.hrllaboratories.com	Research institute
Northrop Grumman	1930	Los Angeles, CA	122,600	$26,206.0	www.northropgrumman.com	Search and detection systems and instruments
Raytheon	1922	Waltham, MA	78,000	$18,109.0	www.raytheon.com	Electronic systems and aircraft
Rofin-Sinar	1975	Hamburg, Germany	235	$114.9	www.rofin-sinar.com	Electrical equipment and supplies
The TRUMPF Group	1923	Ditzingen, Germany	5,561	$1,353.5	www.trumpf.com	Machine tools, metal forming type
Optical Energy Weapons: Electrically Driven, Solid-State, High-Energy Laser - Amplifier						
Coherent Inc.	1966	Santa Clara, CA	2,136	$406.2	www.coherentinc.com	Laser scientific and engineering instruments
JDS Uniphase	1979	Santa Rosa, CA	6,041	$635.0	www.jdsu.com	Manufacture optical instruments/lenses manufacture unsupported plastic film/sheet
Molecular Technology GmbH	1990	Berlin, Germany	N/A	N/A	www.mt-berlin.com	Development of new materials, components, as well as technologies, especially in the fields "lasers, optics, electronics"
Northrop Grumman	1930	Los Angeles, CA	122,600	$26,206.0	www.northropgrumman.com	Search and detection systems and instruments
Rofin-Sinar	1975	Hamburg, Germany	235	$114.9	www.rofin-sinar.com	Electrical equipment and supplies
Saint-Gobain	1937	Paris, France	96	$36.1	www.saint-gobain.com	Durable goods
Optical Energy Weapons: Electrically Driven, Solid-State, High-Energy Laser – Laser Cavity						
BAE Systems	1977	Bristol, United Kingdom	68,400	$14,911.2	www.baesystems.com	Systems integration, complex software and hardware development and advanced manufacturing of military aircraft, surface ships, submarines, space systems, radar, avionics, C4ISR, electronic systems, guided weapons and a range of other defense products
HRL Laboratories	2000	Malibu, CA	340	$80.0	www.hrllaboratories.com	Research institute
Northrop Grumman	1930	Los Angeles, CA	122,600	$26,206.0	www.northropgrumman.com	Search and detection systems and instruments
Raytheon	1922	Waltham, MA	78,000	$18,109.0	www.raytheon.com	Electronic systems and aircraft
Rofin-Sinar	1975	Hamburg, Germany	235	$114.9	www.rofin-sinar.com	Electrical equipment and supplies
The TRUMPF Group	1923	Ditzingen, Germany	5,561	$1,353.5	www.trumpf.com	Machine tools, metal forming type

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Optical Energy Weapons: Electrically Driven, Solid-State, High-Energy Laser – Laser Diode Array						
Armstrong Laser Technology	1999	Freeport, PA	N/A	N/A	www.armstronglaser.com	Laser and electro-optics manufacturing
B&W TEK, Inc.	1996	Newark, DE	46	$4.6	www.bwtek.com	Manufacture laser instrument and related devices and services
Hamamatsu Photonics, K.K.	1953	Hamamatsu City, Japan	3,016	453,	www.usa.hamamatsu.com	Electron tube manufacturing
JENOPTIK	1991	Jena, Germany	10,363	$2,485.2	www.jenoptik.com	Special optical components, optical sensors, laser instruments, infrared cameras, special purpose machines.
Northrop Grumman	1930	Los Angeles, CA	122,600	$26,206.0	www.northropgrumman.com	Search and detection systems and instruments
Thales Laser Diodes	1989	Cedex, France	86	$11.5	www.laser-diodes.thomson-csf.com	Broad range of high power laser diodes and laser diodes for gas sensors
Propulsion: Electromagnetic/Pulsed Plasma Thruster						
Aerojet	1944	Sacramento, CA	2,700	$1,192.0	www.aerojet.com	Non-commercial research and development laboratory
Science Research Laboratory, Inc	1983	Somerville, MA	20	$5.0	World.std.com	Non-commercial research and development laboratory
Propulsion: Hypersonic Weapons Propulsion System						
ATK GASL	2003	Ronkonkoma, NY	99	$8.9	www.atk.com	Aerospace research and development specializing in hypersonics
Bayern-Chemie Protac	1994	Aschau, Germany	300	N/A	www.bayernchemie-protac.com	Hypervelocity propulsion
Propulsion: Miniaturized UAV Turbine Engine						
Aerodyne Research Inc.	1970	Billerica, MA	50	N/A	www.aerodyne.com	Miniature generator
AMT Netherlands	1991	Helmond, Netherlands	N/A	N/A	www.amtjets.com	Designs and manufactures small gas turbines
Baird Micro Turbines (BMT)	N/A	Cape Town, South Africa	N/A	N/A	www.bairdtech.com	Analog and digital electronic circuit design and development
M-DOT Aerospace	1989	Phoenix, AZ	25	$2.1	www.m-dot.com	Aviation and/or aeronautical engineering
SWB Turbines	1992	Neenah, WI	N/A	N/A	www.swbturbines.com	Manufacture micro-turbine engines
TurboJet Technologies (TJT)	1990	Perth, Western Australia	70	N/A	www.tjt.bz	Micro jet turbine engine development
Propulsion: Scramjet						
Alliant Techsystems (ATK) GASL	2003	Ronkonkoma, NY	99	$8.9	www.atk.com	Aerospace research and development specializing in hypersonics
Aerojet	1944	Sacramento, CA	2,700	$1,192.0	www.aerojet.com	Ammunition components
Pratt & Whitney	1925	East Hartford, CT	650	$68.6	www.pratt-whitney.com	Non-commercial research and development laboratory
QinetiQ	2001	Farnborough, England	88,898	$1,414.8	www.QinetiQ.com	Private/public provider of research and engineering services for the UK
Propulsion: Scramjet – Combustion Chamber						
Alliant Techsystems (ATK) GASL	2003	Ronkonkoma, NY	99	$8.9	www.atk.com	Aerospace research and development specializing in hypersonics
Aerojet	1944	Sacramento, CA	2,700	$1,192.0	www.aerojet.com	Ammunition components
Pratt & Whitney	1925	East Hartford, CT	650	$68.6	www.pratt-whitney.com	Non-commercial research and development laboratory
QinetiQ	2001	Farnborough, England	88,898	$1,414.8	www.QinetiQ.com	Private/public provider of research and engineering services for the UK

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Propulsion: Scramjet - Nozzle						
Alliant Techsystems (ATK) GASL	2003	Ronkonkoma, NY	99	$8.9	www.atk.com	Aerospace research and development specializing in hypersonics
Aerojet	1944	Sacramento, CA	2,700	$1,192.0	www.aerojet.com	Ammunition components
Pratt & Whitney	1925	East Hartford, CT	650	$68.6	www.pratt-whitney.com	Non-commercial research and development laboratory
QinetiQ	2001	Farnborough, England	88,898	$1,414.8	www.QinetiQ.com	Private/public provider of research and engineering services for the UK
Propulsion: Multi-Legged UGVs Propulsion System						
Fraunhofer AIS	N/A	Sankt Augustin, Germany	8,725	$705.5	www.ais.fraunhofer.de	Robotics
Iguana Robotics	1999	Urbana, IL	N/A	N/A	www.iguana-robotics.com	Manufacture advanced robotics inspired by information processing in biological systems
iRobot	1992	Burlington, MA	120	$13.5	www.irobot.com	Manufacture robots
Rorschungszentrum Informatik (Research Center for Information Technology)	1985	Karlsruhe, Germany	100	$10.0	www.fzi.de	Non-profit contract research organization that concentrates its efforts on novel information technologies
Royal Military Academy Laboratory	1990	Royal Military Academy Laboratory	5	N/A	mecatron.rma.ac.be	Study and development of mobile legged robots and the control of mobile robots
Thorpe Seeop Corp	1993	Mesa, AZ	25	$1.6	www.seeop.com	Manufacture, operate, and service remote sensor aircrafts
Propulsion: Multi-Legged UGVs Propulsion System – Power Board						
Fraunhofer AIS	N/A	Sankt Augustin, Germany	8,725	$705.5	www.ais.fraunhofer.de	Robotics
Iguana Robotics	1999	Urbana, IL	N/A	N/A	www.iguana-robotics.com	Manufacture advanced robotics inspired by information processing in biological systems
iRobot	1992	Burlington, MA	120	$13.5	www.irobot.com	Manufacture robots
Rorschungszentrum Informatik (Research Center for Information Technology)	1985	Karlsruhe, Germany	100	$10.0	www.fzi.de	Non-profit contract research organization that concentrates its efforts on novel information technologies
Royal Military Academy Laboratory	1990	Royal Military Academy Laboratory	5	N/A	mecatron.rma.ac.be	Study and development of mobile legged robots and the control of mobile robots
Thorpe Seeop Corp	1993	Mesa, AZ	25	$1.6	www.seeop.com	Manufacture, operate, and service remote sensor aircrafts
Propulsion: Multi-Legged UGVs Propulsion System – Robotic Leg						
Fraunhofer AIS	N/A	Sankt Augustin, Germany	8,725	$705.5	www.ais.fraunhofer.de	Robotics
Iguana Robotics	1999	Urbana, IL	N/A	N/A	www.iguana-robotics.com	Manufacture advanced robotics inspired by information processing in biological systems
iRobot	1992	Burlington, MA	120	$13.5	www.irobot.com	Manufacture robots
Rorschungszentrum Informatik (Research Center for Information Technology)	1985	Karlsruhe, Germany	100	$10.0	www.fzi.de	Non-profit contract research organization that concentrates its efforts on novel information technologies
Royal Military Academy Laboratory	1990	Royal Military Academy Laboratory	5	N/A	mecatron.rma.ac.be	Study and development of mobile legged robots and the control of mobile robots
SRI International	1946	Menlo Park, CA	1,400	$220.0	www.sri.com	Independent, nonprofit research institute

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
RF Energy Weapons: Suitcase-Sized, High-Powered Electromagnetic Pulse (EMP) Device						
Schriner Engineering	N/A	Ridgecrest, CA	N/A	N/A	N/A	Built a radio frequency weapon capable of destroying the electronic devices
RF Energy Weapons: Suitcase-Sized, High-Powered Electromagnetic Pulse (EMP) Device – Explosively Pumped Flux Generator						
Los Alamos Neutron Science Center (LANSCE)	1943	Los Alamos, NM	1,400	$90.7	www.lansce.lanl.gov	Commercial physical research
RF Energy Weapons: Suitcase-Sized, High-Powered Electromagnetic Pulse (EMP) Device – Compact, High-Power Spark Generator						
Applied Physical Electronics, L.C.	1998	Austin, TX	3	$1.0	www.apelc.com	Marx generators, trigger generators, solid state impulse circuits, photoconductive switching, optical systems, high voltage impulse antennas, high power microwave loads, high voltage/ultra fast transient event diagnostics, and computation electromagnetics
Bhabha Atomic Research Centre	1944	Mumbai, India	N/A	N/A	www.barc.ernet.in	Multi-disciplinary Nuclear Research Centre of India having excellent infrastructure for advanced Research and Development with expertise covering the entire spectrum of Nuclear Science and Engineering and related areas
Ion Physics	1972	Freemont, NH	N/A	N/A	www.ionphysics.com	Supplier of Current Monitors and High Voltage Pulse Generators
Physique & Industrie	1993	Marsonnay la cote, France	N/A	N/A	www.physiqueindustrie.com	Provides research and development for other industrial companies, to design innovative leading edge products using the state of the art of the technology, ranging from environmental solutions to high power pulse generators
Samtech, Ltd	1999	Glasgow, U.K	N/A	N/A	www.samtech.co.uk	Development and production of pulsed power products
Titan Corporation, Pulse Sciences Division	N/A	San Leandro, CA	70	$6.4	www.titan.com	Built pulp energy beam system for the government
RF Energy Weapons: Ultra-Wideband Pulse-Power HPM Device						
Gramat Research Center	N/A	Gramat, France	N/A	N/A	www.onera.fr	Public scientific and technical establishment involved in aircraft, spacecraft and missile design
Institut Saint-Louis (ISL)	1959	Saint-Louis, France	410	N/A	www.isl.tm.fr	Colleges and universities
Raytheon	1997	Tucson, AZ	11,000	$1,132.5	www.raytheon.com	Guided missiles and space vehicles
Rosboronexport	N/A	Moscow, Russia	N/A	N/A	www.roe.ru	Sole state intermediary agency for Russia's military exports/imports

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
RF Energy Weapons: Ultra-Wideband Pulse Power HPM Device – Compact, Efficient, High-Power Pulse Power Driver						
Directed Energy Directorate of the Air Force Research Laboratory	N/A	Kirtland Air Force Base, NM	600	$130.0	www.de.afrl.af.mil	Develop, integrate, and transition science and technology for directed energy to include high power microwaves, lasers, adaptive optics, imaging, and effects
FID Technology, Ltd	1997	St. Petersburg, Russia	N/A	N/A	N/A	N/A
Institute for Electromagnetic Research	N/A	Kharkov, Ukraine	N/A	N/A	N/A	Research institute
The Institute of Electrophysics, Russian Academy of Sciences	1986	Ekaterinburg, Russia	200	N/A	eng.iep.uran.ru	Research institute
Titan Corporation	1910	San Diego, CA	11,500	$1,775.0	www.titan.com	Technology developer and systems integrator that provides a range of systems solutions and services primarily for the Department of Defense
University of Texas Institute for Advanced Technology (IAT)	1990	Austin, TX	N/A	N/A	www.iat.utexas.edu	Basic and applied research in electrodynamics, hypervelocity physics, pulsed power, and education in related critical technologies
RF Energy Weapons: Ultra-Wideband Pulse Power HPM Device - Compact, High-Peak-Power, or High-Average-Power HPM Source						
AVX Corporation, owned by Kyocera	1990	Koyoto, Japan	13,150	$1,136.6	www.kyocera.co.jp	Manufacture electronic capacitors and connectors
Maxwell Technologies, Inc.	1965	San Diego, CA	285	$45.0	www.maxwell.com	Pulsed power systems and power conversion equipment application software
NEC	1899	Tokyo, Japan	143,393	$47,022.0	www.nec.com	Electronic computer manufacturing
Sigma Technologies International, Inc.	1992	Tucson, AZ	37	$6.4	www.sigma-technologies.com	Metal Coating
TDK	1935	Tokyo, Japan	34,535	$2,758.0	www.tdk.com	Electronic components
TPL, Inc	1991	Albuquerque, NM	76	$7.7	www.tplinc.com	Leader in the development of nano-sized ceramic powders and advanced organic and inorganic dielectric systems for the world-wide electronics industry
Special Purpose Weapons: Polymer Interferant						
Los Alamos National Laboratory	1943	Los Alamos, NM	10,700	$2,200.0	www.lanl.gov	Major research complex
RETA Security	1984	Lemont, IL	2	$0.3	www.retasecurity.com	Security consulting engineering and training
Sandia National Laboratory	1949	Albuquerque, NM	8,000	$470.9	www.sandia.gov	Non-commercial research organization
Special Purpose Weapons: Self-Propagating High-Temperature Synthesis (SHS) Device						
General Sciences, Inc.	1982	Souderton, PA	12	$1.3	www.general-sciences.com	Testing laboratory
Texas A&M University	1876	College Station, TX	N/A	N/A	www.tamu.edu	Major university
The Institute of Structural Macrokinetics, Russian Academy of Sciences (ISMAN)	1987	Chernogolovka, Russia	N/A	N/A	www.ism.ac.ru	Research institution engaged in the studies on macroscopic kinetics of chemical reactions

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Special Purpose Weapons: Self-Propagating High-Temperature Synthesis (SHS) Device – Metal and Inter-Metallic Nano-Powder						
Argonide	1994	Sanford, FL	8	$0.5	www.argonide.com	Manufacture miscellaneous fabricated metal products lab chemicals industrial filters
Morgan Group Technology Ltd	1856	Windsor , UK	16,093	$1,501.4	www.morgancrucible.com	Develop and supply a broad range of products made from carbon, ceramic and magnetic materials
Nano-Powders Industries	1997	Ceasarea, Israel	20	$0.2	www.nanopowders.com	Nanosized metal powders
Nano-Technologies	1999	Austin, Texas	22	$0.9	www.nano-scale.com	Manufacture and research and development of nano metals and oxides
TAL Materials, Inc.	1996	Ann Arbor, MI	8	N/A	www.talmaterials.com	Nanopowder-based research and development solutions
Tetronics	1998	Oxfordshire , U.K	30	$3,434.7	www.tetronics.com	Designers and manufacturers of High Temperature Plasma and equipment
Structures: Hypersonic Transatmospheric Vehicle, High-Stress-Tolerant Structural Materials Overview						
Alliant Techsystems (ATK) GASL	2003	Ronkonkoma, NY	99	$8.9	www.atk.com	Aerospace research and development specializing in hypersonics
Aviabor	1960	Dzerzhinsk, Russia	1,250	N/A	www.aviabor.com	Production of boron compounds for commercial purposes
FMW Composite Systems, Inc.	2002	Bridgeport, WV	61	$5.2	www.fmwcomposite.com	Manufacture of composite products
QinetiQ	2001	Farnborough, England	88,898	$1,414.8	www.QinetiQ.com	Private/public provider of research and engineering services for the UK
SGL Carbon Group	1928	Wiesbaden, Germany	7,077	$1,205.6	www.sglcarbon.com	Industrial inorganic chemicals
Specialty Materials, Inc	2001	Lowell, MA	36	$7.2	www.specmaterials.com	Manufacturer of boron and silicon carbide fibers
Structures: Hypersonic Transatmospheric Vehicle, High-Stress-Tolerant Structural Materials – Boron Epoxy Composite						
Advanced Composites	1981	Unanderra, Australia	N/A	N/A	www.advcomposites.com.au	Supplier of materials and equipment to the aerospace and composites industries
Aviabor	1960	Dzerzhinsk, Russia	60	N/A	www.aviabor.com	Hi-tech manufacturer of boron compounds
Composites, Inc	1980	Manchester, CT	N/A	N/A	www.compositesinc.com	Composites
Goodrich	1870	Charlotte, NC	22,900	$4,382.9	www.goodrich.com	Manufacture of aircraft parts and components and aircraft MR&O
Specialty Materials, Inc	2001	Lowell, MA	36	$7.2	www.specmaterials.com	Manufacturer of boron and silicon carbide fibers
Structures: Hypersonic Transatmospheric Vehicle, High-Stress-Tolerant Structural Materials – Graphite Epoxy Composite						
AAE Aerospace	1967	Huntington Beach, CA	60	N/A	www.aaeaerospace.com	Rocket propulsion insulation and composite structures
Aeroform	N/A	Dorset, England	50	$14.0	www.aeroform.co.uk	Aircraft engineers
Alliant Techsystems (ATK) GASL	2003	Ronkonkoma, NY	99	$8.9	www.atk.com	Aerospace research and development specializing in hypersonics
Hexcel	1946	Stamford, CT	4,245	$896.9	www.hexcel.com	Manufacture reinforced fiberglass honeycomb materials and advanced composites
Nippon Graphite Fiber	1995	Tokyo, Japan	N/A	N/A	www.ngfworld.com	Pitch based carbon fiber, fabric, and prepreg
SGL Carbon Group	1928	Wiesbaden, Germany	7,077	$1,205.6	www.sglcarbon.com	Industrial inorganic chemicals

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Structures: Hypersonic Transatmospheric Vehicle, High-Stress-Tolerant Structural Materials – Titanium Metal Matrix						
FMW Composite Systems, Inc.	2002	Bridgeport, WV	61	$5.2	www.fmwcomposite.com	Manufacturer of composite products
QinetiQ	2001	Farnborough, England	88,898	$1,414.8	www.QinetiQ.com	Private/public provider of research and engineering services for the UK
Specialty Materials, Inc	2001	Lowell, MA	36	$7.2	www.specmaterials.com	Manufacturer of boron and silicon carbide fibers
Structures: Multi-functional Structures						
BAE Systems	1977	Bristol, United Kingdom	68,400	$14,911.2	www.baesystems.com	Design, manufacture, and support military aircraft, surface ships, submarines, space systems, radar, avionics, C4ISR, electronic systems
ITN Energy Systems	2001	Littleton, CO	67	$10.7	www.itnes.com	Research, development, and engineering services
Lockheed Martin	1909	Bethesda, MD	130,000	$31,824.0	www.lockheedmartin.com	Design, manufacture, and integration of advanced technology products and services for the US government and private industry
QinetiQ	2001	Farnborough, England	88,898	$1,414.8	www.QinetiQ.com	Private/public provider of research and engineering services for the UK
Telecordia Technologies (subsidiary of SAIC)	1997	Piscataway, NJ	N/A	N/A	www.telcordia.com	Serves the wireline, mobile, cable, government, and equipment supplier markets
Structures: Small-Caliber Projectile Control Surface						
Auburn University	1956	Auburn, AL	7,008	N/A	www.auburn.edu	Major university
Bofors Defence	1980	Karlskoga, Sweden	200	$112.8	www.boforsdefense.com	Ordnance and accessories
Deihl Stiftung & Co.	1902	Nuremberg, Germany	10,600	$2,006.0	www.diehl.com	Ammunition, missiles, surveillance systems, cockpit and display systems, avionics, vehicle systems, flight and engine controls, and cabin and utility systems
Giat Industries	1990	Versailles-Satory, France	6,000	$914.0	www.giat-industries.fr	French state-owed tank and weapons systems manufacturer
Lockheed Martin	1909	Bethesda, MD	130,000	$31,824.0	www.lockheedmartin.com	Design, manufacture, and integration of advanced technology products and services for the US government and private industry
Piezo Systems, Inc	N/A	Cambridge, MA	7	$0.9	www.piezo.com	Manufacture actuators
Structures: Ultra-High-Temperature Materials						
BFGoodrich Company (Rohr)	1940	Richfield, OH	250	$17.2	www.aerostructures.goodrich.com	Plastic materials/resins and chemical preparations
DuPont	1802	Wilmington, DE	67,500	$27,730.0	www.dupont.com	Manufacture agricultural chemicals manufacture fibers specialty chemicals and high performance materials
General Electric Company (GE)	1892	Fairfield, CT	331,475	$134,187.0	www.ge.com	Diverse financial services and manufacturing business
Saint-Gobain	1937	Paris, France	96	$36.1	www.saint-gobain.com	Durable goods
Sigri Great Lakes Carbon, GmBH	1992	Wiesbaden, Germany	6,826	$1,311.4	www.sglcarbon.com	Manufacturers of products made of carbon, graphite and composite materials for industrial and aerospace applications.
Solvay, SA	1863	Brussells, Belgium	30,000	$9,485.5	www.solvay.com	Specialty chemical solutions in three sectors: chemicals, plastics, and pharmaceuticals

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Structures: Ultra-High-Temperature Materials – Carbon Composites						
Anaori Carbon Co., Ltd.	1961	Takatsuki, Japan	N/A	N/A	www.anaori.co.jp	Carbon and graphite products
BFGoodrich Company (Rohr)	1940	Richfield, OH	250	$17.2	www.aerostructures.goodrich.com	Plastic materials/resins and chemical preparations
Fiber Materials, Inc	1969	Biddeford, ME	150	$11.8	www.fibermaterialsinc.com	Composites for guided missiles and space vehicle parts
Nippon Carbon Co.	1915	Tokyo, Japan	561	$144.6	www.carbon.co.jp	Carbon and graphite products
SGL Carbon Group	1928	Wiesbaden, Germany	7,077	$1,205.6	www.sglcarbon.com	Industrial inorganic chemicals
The Boeing Company	1916	Chicago, IL	166,070	$50,485.0	www.boeing.com	Commercial and military aircraft and defense electronics
Structures: Ultra-High-Temperature Materials – Ceramic Matrix						
General Electric Company (GE)	1892	Fairfield, CT	331,475	$134,187.0	www.ge.com	Diverse financial services and manufacturing business
Morgan Crucible Co. plc	1856	Berkshire, England	16,093	$1,501.4	www.morgancrucible.com	Develop and supply a broad range of products made from carbon, ceramic and magnetic materials
Rockwell Scientific	2001	Thousand Oaks, CA	450	$33.7	www.rsc.rockwell.com	Commercial physical research organization
Saint-Gobain	1937	Paris, France	96	$36.1	www.saint-gobain.com	Durable goods
Snecma Group	1905	Paris, France	35,609	$68,168.0	www.snecma.com	Aircraft and rocket propulsion
Starfire Systems, Inc.	1988	Malta, NY	19	$0.3	www.starfiresystems.com	Ceramic matrix composites for high temperature structural components and hot gas filtration
Structures: Ultra-High-Temperature Materials – High Temperature Polymers						
BASF, AG	1865	Germany	87,000	$41,922.9	www.basf.com	Chemical company with a portfolio range from chemicals, plastics, performance products, agricultural products and fine chemicals to crude oil and natural gas
Dow Chemical Company	1897	Midland, MI	46,372	$32,632.0	www.dow.com	Plastic materials/resins
DuPont	1802	Wilmington, DE	67,500	$27,730.0	www.dupont.com	Manufacture agricultural chemicals manufacture fibers specialty chemicals and high performance materials
General Electric Company (GE)	1892	Fairfield, CT	331,475	$134,187.0	www.ge.com	Diverse financial services and manufacturing business
Solvay, SA	1863	Brussells, Belgium	30,000	$9,485.5	www.solvay.com	Specialty chemical solutions in three sectors: chemicals, plastics, and pharmaceuticals
Victrex PLC	1981	Lancashire, U.K.	222	$94.8	www.victrex.com	Victrex® PEEK™ polymer is a high performance thermoplastic
Weapons Fuses: Prerelease Selectable Penetration Fuse						
ATK Ordnance	1990	Plymouth, MN	12,000	$2,366.2	www.atk.com	Manufacture aerospace and defense systems and ordinance reclamation
BT Fuze Products	2001	Lancaster, PA	250	$9.2	www-btfuze.tw.l-3com.com	Manufacture radio/TV communication equipment
KDI Precision Products, Inc.	1998	Cincinnati, OH	240	$57.3	www.kdi-ppi.com	Manufacture arming and fusing devices for missiles and artillery
Motorola Israel, Ltd.	1986	Tel Aviv, Israel	4,116	$830.4	israel.motorola.com	Communications equipment
TDA Armaments	1994	La Ferte Saint Aubin, France	500	$96.6	www.tda-arm.fr	Military armored vehicle, tank, and tank component manufacturing
Thales Missile Electronics, Ltd.	1968	Basingstoke, U.K.	356	$41.6	www.thalesgroup.com/airbornesystems	Design of fuses and electronic components

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Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Weapons Fuses: Prerelease Selectable Penetration Fuse – Precision Accelerometer						
Elbit Systems, Ltd	1996	Haifa, Israel	5,050	$883.1	www.elbitsystems.com	Electrical equipment and supplies
Honeywell Defense and Space Electronics	1885	Redmond, WA	754	$65.5	www.honeywell.com	Plastic materials/resins and search/navigation equipment
Jewell Instruments	2000	Manchester, NH	220	$15.6	www.jewellinstruments.com	Measure/control devices and search/navigation equipment
Robert Bosch Gmbh	1886	Stuttgart, Germany	232,000	$45,635.3	www.bosch.com	Automotive, industrial, and building technologies provider
Silicon Designs, Inc.	1983	Issaquah, WA	21	$2.4	www.silicondesigns.com	Electrical measuring instruments and process control instruments
TDA Armaments	1994	La Ferte Saint Aubin, France	500	$96.6	www.tda-arm.fr	Military armored vehicle, tank, and tank component manufacturing
Weapons Fuses: Void Detection Fuse						
ATK Ordnance	1990	Plymouth, MN	12,000	$2,366.2	www.atk.com	Ordnance reclamation for aerospace and defense systems
BT Fuze Products	2001	Lancaster, PA	250	$9.2	www-btfuze.tw.l-3com.com	Radio/TV communication equipment
KDI Precision Products, Inc.	1998	Cincinnati, OH	240	$57.3	www.kdi-ppi.com	Arming and fusing devices for missiles and artillery
Motorola Israel, Ltd.	1986	Tel Aviv, Israel	4,116	$830.4	israel.motorola.com	Communications equipment
TDA Armaments	1994	La Ferte Saint Aubin, France	500	$96.6	www.tda-arm.fr	Military armored vehicle, tank, and tank component manufacturing
Thales Missile Electronics, Ltd.	1968	Basingstoke, U.K.	356	$41.6	www.thalesgroup.com/airbornesystems	Fuses and electronic components
Weapons Guidance and Control: Acquisition Tracking and Pointing Laser						
Azimuth Technology Ltd.	1987	Raanana, Israel	N/A	N/A	www.azimuth.co.il	Target acquisition, fire coordination, navigation and orientation solutions for defense markets
Carl Zeiss	1846	Oberkochen, Germany	14,229	$2,234.0	www.zeiss.de	Optical instruments and lenses
EADS	2000	Paris, France	109,135	$37,822.9	www.eads-nv.com	Aeronautic, aerospace and defense company
Lockheed Martin Missiles and Fire Control	1909	Bethesda, MD	130,000	$31,824.0	www.lockheedmartin.com	Develop, manufacture, and support advanced combat, missile, rocket and space systems
Northrop Grumman	1930	Los Angeles, CA	122,600	$26,206.0	www.northropgrumman.com	Search and detection systems and instruments
Raytheon	1922	Waltham, MA	78,000	$18,109.0	www.raytheon.com	Electronic systems and aircraft
Weapons Guidance and Control: Aiming and Lock-on Laser						
BAE Systems North America	1977	Nashua, NH	1,100	$4,500.0	www.baesystems.com	Mission support, message handling, and data management
CILAS	1966	Marcoussis, France	237	$24.6	www.cilas.com	Search/navigation equipment
Lockheed Martin Missiles and Fire Control	1909	Bethesda, MD	130,000	$31,824.0	www.lockheedmartin.com	Develop, manufacture, and support advanced combat, missile, rocket and space systems
MBDA	1990	London, U.K.	2,900	$1,040.8	www.mbda.co.uk	Military armored vehicle, tank, and tank component manufacturing
Raytheon	1922	Waltham, MA	78,000	$18,109.0	www.raytheon.com	Manufacture electronic systems and aircraft
Thales	1968	Cedex, France	71,309	$1,761.3	www.thalesgroup.com	Search, detection, navigation, guidance, aeronautical, and nautical systems

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Sources: SEC Filings, Orbis Bureau van Dijk databases, RDS Business and Industry database, LexisNexis Academic Universe, S&P reports, Hoover's, US Major Companies Database, Yahoo Finance, US Business Directory, Dun & Bradstreet, and First Equity research.

Technology Suppliers [1]						
Company Name	**Est.**	**Location**	**Employees**	**Sales (US$M)**	**Website**	**Technology / Line of Business**
Weapons Guidance and Control: Jitter and Vibration Management System						
CSA Engineering, Inc	1982	Mountain View, CA	44	$11.0	www.csaengineering.com	Vibration noise and precision motion control
Goodrich	1870	Charlotte, NC	22,900	$4,382.9	www.goodrich.com	Manufacture aircraft parts and components and perform aircraft MR&O
Lockheed Martin Space Systems	1909	Sunnyvale, CA	6,000	$647.3	www.lmco.com	Manufacture missiles,space vehicles, and radio/TV communication equipment
Weapons Guidance and Control: Jitter and Vibration Management System – Fast Steering Mirror						
Axsys Technologies	1959	Rocky Hill, CT	587	$85.1	www.axsys.com	Manufacture precision optical and positioning components and industrial components
Ball Aerospace and Technologies Corp	1995	Boulder, CO	2,750	$491.0	www.ball.com	Engineering services and manufacturing of search/navigation equipment
Carl Zeiss	1999	Oberkochen, Germany	14,229	$2,234.0	www.zeiss.de	Optical instruments and lenses
Trex Enterprises	2000	San Diego, CA	150	$29.0	www.trexenterprises.com	Contract research and technology development services
Weapons Guidance and Control: Jitter and Vibration Management System – Passive Isolator						
CSA Engineering, Inc	1982	Mountain View, CA	44	$11.0	www.csaengineering.com	Vibration noise and precision motion control
Everlasting Progress	1999	Kyonggi-Do, Korea	N/A	N/A	www.elp.co.kr	Weapons support
GERB GmbH	1907	Berlin, Germany	135	$15.5	www.gerb.com	Steel spring (except wire) manufacturing
Kinetic Systems	1968	Boston, MA	50	$4.4	www.kineticsystems.com	Manufacture measure/control devices and optical instruments/lens
Newport Corporation	1938	Irving, CA	1,742	$134.8	www.newport.com	Manufacture vibration isolation worktables, laser and electro-optical components, and analytical optical and laser instruments
Stop-Choc Ltd.	N/A	Slough, U.K.	1,000	$188.1	www.stopchoc.co.uk	Design and manufacture vibration and shock isolation systems in high performance elastomers, all metal mountings using stainless steel resilient cushions and cable mounts

[1] **Companies listed are representative; the list is not exhaustive. Inclusion or exclusion does not imply future business opportunities with or endorsement by DoD.**
Sources: SEC Filings, Orbis Bureau van Dijk databases, RDS Business and Industry database, LexisNexis Academic Universe, S&P reports, Hoover's, US Major Companies Database, Yahoo Finance, US Business Directory, Dun & Bradstreet, and First Equity research.

APPENDIX D

POLICY PORTALS AND LEVERS

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MAJOR INNOVATION PORTALS AND POLICY LEVERS IN THE INDUSTRIAL PROCESS[1]

ODUSD(IP) has developed a policy construct to incentivize innovation in industrial base capabilities and to remedy deficiencies. This policy construct promotes a systematic approach to address industrial base development and avoid deficiencies.

Maintaining the U.S. warfighting advantage requires continuous innovation of critical warfighting capabilities. Key among many factors driving innovation is competition among ideas and the application of those ideas. Ideally, the Department would like more competition for the most critical warfighting capabilities, those facilitating asymmetric advantages. Ideally, as well, the Department would seek to lower risks by choosing and developing domestic suppliers to provide those technologies where the United States wants to have warfighting capabilities superior to those of potential adversaries. Clearly, however, we would not deprive the warfighter when a foreign source has the best solution. By the same token, the Department also seeks to ensure that key technology is protected through export controls and other interagency measures. However, as the criticality of the warfighting capability lessens, the need for competitive U.S. sources to drive innovation of that capability also lessens.

Portals and Levers for Policy Implementation

Management of critical industrial capabilities requires policy implementations. There are three major policy levers that can be used to remedy instances in which required industrial capabilities are insufficient: (1) fund innovation; (2) optimize program management structures and acquisition strategies; and (3) apply external corrective measures where warranted.

These levers are best employed through the five openings or portals into the acquisition process where we believe the most effective influence on the industrial base can be achieved. These key opportunities to innovate the industrial base are: (1) science and technology (S&T); (2) the transition from laboratory to manufacturing; (3) weapon system design; (4) make/buy decisions; and (5) life cycle innovation.

The Department's challenge is to identify, monitor, and act to ensure that the critical technologies and industrial capabilities required to develop and field warfighting capabilities are sufficient in number and have the level of innovation necessary to meet projected DoD requirements. In addition, our assessment that technologies were critical enough to assess on a priority basis was based on the

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[1] Excerpt taken from *DIBCS BA*, Part III, published January 2004. Therefore, illustrative examples given in this Appendix are primarily BA resources.

multiple application of these technologies. As a consequence, these recommended actions might also foster applying critical technologies across multi-Service joint applications. By highlighting industrial base deficiencies for critical technologies and implementing appropriate policy initiatives and remedies, the Department will continue to foster the innovative industrial base that is the basis of our warfighting advantage.

How Portals and Levers Work

Our analysis led us to focus on the five primary portals through which the Department can assure sufficiency of sources and innovation—and potentially also tap into particularly innovative technology to pollinate it among other applications. Acquisition policy guidance encourages Department acquisition professionals to appropriately deploy policy levers through these portals as a normal practice throughout the industrial processes that define a program. However, such guidance sometimes is overcome by other programmatic priorities. Particularly in cases where required industrial capabilities are insufficient or have cross-platform utility, remedial action may help optimize outcomes.

Early in responding to an emerging warfighting requirement, critical industrial capabilities may be resident in too few potential suppliers to generate confidence in timely success. For example, when developing or applying a new technology or developing a missing key system or systems enabler, sources may be limited to the incumbent suppliers of the previous generation of that technology, such as in the development of Global Hawk, which is discussed later in this Appendix. The available sources may also not be able to address multiple applications of a given technology. The Department should be prepared to act in such situations.

Later, in concept development or weapon system development and design, the number of potential suppliers may be insufficient to generate innovation or price competition due to industry consolidation, teaming arrangements, waning interest, or other factors. The Navy's Future Destroyer (DDX) program is a good example of an instance in which the Department acted in such a situation to ensure the availability of an innovative, competitive industrial base.

For mature systems or in mature industries, contractors may choose to source commonly available components from the global industrial base for reasons of best performance and cost. Additionally, older systems may be so far removed from the state-of-the-art that domestic suppliers deliberately discontinue producing necessary subsystems and components. While the Department is less concerned as a whole about such situations, it should act in the make-buy decisions and throughout programs' life cycles to induce innovation as much as possible.

In our construct, management decisions and options can be examined systematically using the array of portals and levers, as discussed in this Appendix. Portals generally correspond to program phases. In the case of applying remedies, the phase of the program determines which portals apply. The *science and technology* portal should be open nearly continuously for the more critical technologies since we should evolve these technologies until they reach their scientific limitations. Optimally, the *make/buy decisions* and the *life cycle innovation* portals are also open nearly continuously once a system is fielded so that technology refresh can be accomplished as necessary. The *transition from lab to manufacturing* and the *weapon systems design* portals represent more limited windows of opportunity. In this construct as illustrated below, once the portal(s) have been determined, the three levers (*fund innovation*, *optimize program management/acquisition strategy*, and *employ external measures*) are systematically considered for how to best influence the desired outcome. The remedy or remedies can then be mapped on the board. This is the construct we will discuss further in the pages that follow: first portals and then levers.

MAJOR INNOVATION PORTALS AND POLICY LEVERS IN THE INDUSTRIAL PROCESS

Portals / Levers	Science & Technology	Lab to Manufacturing	Weapon System Design	Make/Buy Decisions	Life Cycle Innovation
Fund Innovation					
Optimize Program Management/ Acquisition Strategy					
Employ External Measures					

Source: ODUSD (IP)

To illustrate the portals and levers, we use a number of examples. These examples include opportunities taken to use a lever effectively and opportunities lost. While the examples come from a variety of programs, the discussion here is focused on industrial base impacts of the action taken or not taken and are not intended to reflect on the overall status or outcome of the program.

INNOVATION PORTALS

This study's focus on innovation is driven by the need to *Be Ahead* or Be *Way Ahead* in critical technologies. As depicted in the graphic on the previous page, there are five major portals of opportunity where managerial decisions determine the likelihood that critical technologies and associated industrial capabilities are developed and sustained expeditiously and cost-effectively:

- *Science & Technology*. Programmatic and funding decisions by both the government and industry involving technology development significantly impact the likelihood that there will be sufficient industrial capabilities to incorporate critical technologies in defense systems. A capabilities-based approach like the DIBCS methodology can serve as a guide for shaping these decisions by stimulating investment in critical industrial base capabilities.

- *Laboratory to Manufacturing Transition*. Manufacturing approaches that optimize either for manufacture by the developer or for only one warfighting application often transition new technologies from the laboratory to production with unintended limitations. For critical enabling technologies like those identified earlier, the Department should encourage manufacturing processes that encourage competitive solutions and enable their transition to other applications. Industrial base concerns must, of course, be balanced against delays that preclude the timely delivery of new operational capabilities to the warfighter.

- *Weapon System Design*. Design practices (for example, the effective use of standard software and hardware interfaces) can encourage innovation. On the other hand, government or prime contractor specifications that are too prescriptive can undermine innovation. This often is the case in subsystems or components that optimize designs around single-supplier products, applications, or technologies. This kind of behavior leads to sub-optimized designs and sole sources. The Department's policy on the use of an open systems approach promotes the use of products from multiple suppliers and allows next generation modules to be inserted to upgrade capabilities throughout the life cycle of the weapon system. A key attribute of evolutionary acquisition and spiral development is planning and managing technology insertion to foster opportunities for new warfighting applications from original—and new—manufacturing sources.

- *Make/Buy Decisions*. Contractor make or buy decisions are the front lines of competition and innovation. For critical technologies, the policy levers should be used within this portal to encourage contractors not to favor in-house capabilities or long-term teammate products over more innovative solutions available elsewhere. When warranted, the

Department will engage actively to shape make/buy decisions. This is not a new policy but requires advanced planning in the acquisition strategy.[2] Unwarranted favoritism, especially if systemic, discourages innovative suppliers. Warfighters lose when contractors try to satisfy critical capability requirements without choosing the most innovative, best-value suppliers.

- *Life Cycle Innovation*. Under evolutionary acquisition strategies, even more so than in the past, fielded defense systems will continue to undergo further development to improve warfighting capabilities. These innovative improvements offer new opportunities to import emerging technological and industrial capabilities that maintain or expand warfighting superiority. Thus, they should draw from the broadest possible spectrum of the overall industrial base. As a consequence, cost-effective commercial practices and standards and open architectures become particularly important.

Traditionally, these portals have been the provinces of a discrete set of industrial base participants aligned to specific phases within the industrial process as shown below.

TRADITIONAL INNOVATION PORTALS AND INDUSTRIAL PROCESS PARTICIPANTS

Program Phases	Science & Technology	Lab to Manufacturing	Weapon System Design	Make/Buy Decisions	Life Cycle Innovation
Participants	Inventors, Academia, Government Labs and R&D Centers, Domestic And Foreign Industry	Service Labs, Program Offices, Industry, Commercial and Government Centers of Excellence (e.g., NCMS, Fraunhofer Institute)	Industry/ Government Program Office	Industry	Industry/ Government Program Office

Source: ODUSD (IP)

For example, inventors, academia, laboratories, government and industry research and development centers, and industry generally all act in the *science and technology* portal. However, as programs proceed through *weapon system design*, *make/buy decisions*, and *life cycle innovation* portals, the breadth of participants generally narrows to include only industry and government program personnel. This practice is akin to premature down-selection, foreclosing access to the broader defense industrial base and reducing innovation potential. Our

[2] Government involvement in make/buy decisions is illustrated in explicit subsystem acquisition strategies like the E-10A (see page D-16), Space Based Radar (see page D-16), as well as the consent decrees associated with the Northrop-Grumman/TRW case (see page D-22). Less extreme measures such as make/buy plans and award fee criteria can be applied routinely.

first example of the *life cycle innovation* portal (and *acquisition strategy* lever) also is an example of broad industrial base participation to solve a critical need.

ARCI EXAMPLE

- Rapid insertion of technology to enhance system performance, including commercial technology
- Use of maximum breadth of industrial base provides for frequent competitions
- Annual portal for technology refresh and innovation prevents Navy from being captive to a single contractor

The Navy applied the *acquisition strategy* lever to induce innovation and competition in submarines as part of *life cycle innovation* in response to advances in world submarine acoustic technology in the mid-1990s. In 1996, the Navy adopted a revolutionary plan to maintain superiority by applying state-of-the-art signal processing in state-of-the-practice COTS hardware and software. The Acoustic Rapid Commercial off-the-shelf (COTS) Insertion (ARCI) program restored the Navy's submarine acoustic superiority and provided an innovative approach to continued improvement.

In ARCI, the Navy uses standard hardware and software interfaces, and a capabilities-based (versus requirements-based) model to integrate skills from the Navy, academia, and small and large businesses. It developed a rigorous process which rapidly inserts advanced capability into the fleet on a regular basis. By partitioning the sonar system into processing strings, the Navy was able to leverage the strengths of the developers and enable a sequential and incremental capability insertion plan. ARCI prime contractor Lockheed Martin provides system integration and system management. Digital Systems Resources, now part of General Dynamics, developed the towed array. The Applied Research Laboratory at the University of Texas developed the high frequency active array; and John Hopkins University's Applied Physics Laboratory served as the advanced technology test program lead. Members of the advanced development community (Navy laboratories, academia, and industry) continue to provide the new ideas, algorithms, and implementations.

The use of standard hardware and software interfaces is fundamental to ARCI's ability to continue innovation throughout the system life cycle. Selecting standard interfaces commonly used throughout industry removes a significant barrier to supplier participation. Nearly any information technology supplier is familiar with internet protocols as well as common hardware architectures, operating systems, and application program interfaces. It is the adaptation of commonly used standards like these to defense requirements that enables participation by the broadest base of suppliers, including emerging defense suppliers. Standard hardware and software interfaces enable a maximum level of innovation for development and continued improvement of critical warfighter capabilities.

While the ARCI example focuses on the *life cycle innovation* portal, we believe that continuous use of these portals provide the best opportunities to influence the current and future sufficiency of the industrial base. Effective collaboration

among all industrial base participants through all program phases makes it possible to access and deploy the best available knowledge and ingenuity. It also makes more certain the Department's ability to identify and employ the appropriate policy levers discussed below to induce and sustain innovation across the breadth of the defense enterprise.

POLICY LEVERS

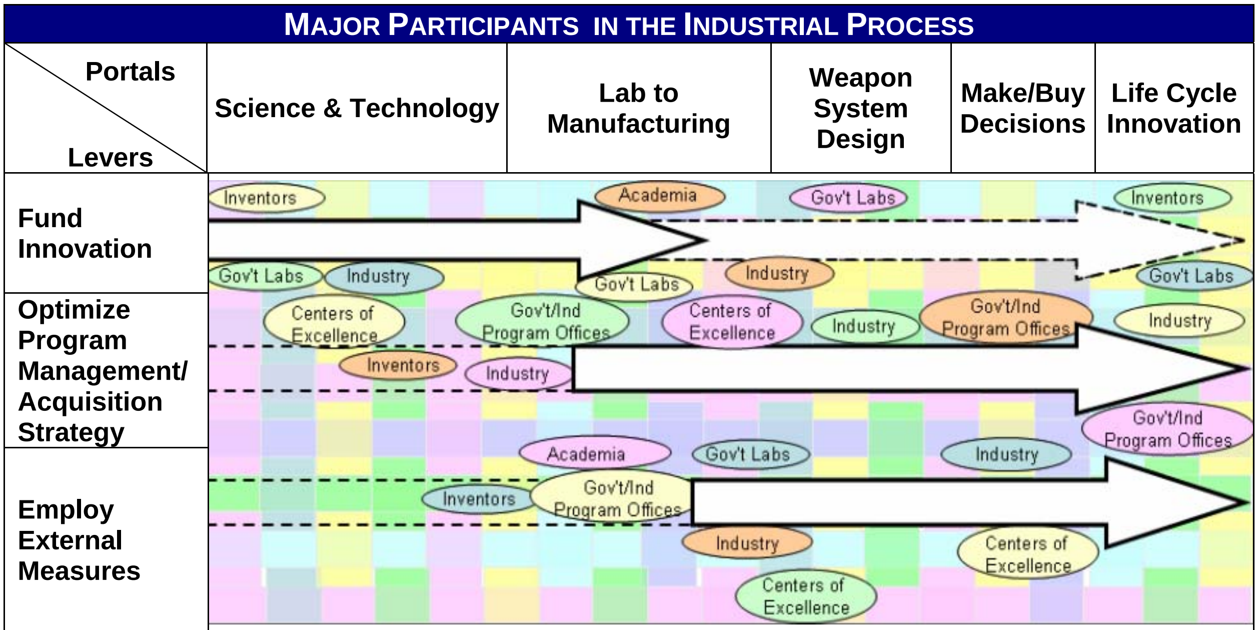
Three major policy levers offer tools with which the Department can develop, sustain, or expand innovation, drawing on the entirety of the industrial base, no matter the phase of the program. Ideally, DoD managers and contractors deploy these levers routinely through the appropriate portals discussed above to develop robust technological solutions to defense problems, insert those technologies, sustain critical industrial capabilities, and leverage those which may have applications elsewhere in the defense enterprise. For those cases where the Department determines that critical technological and industrial capabilities are deficient, it should carefully define the concern and use the appropriate lever to remedy the deficiency. For example, in the ARCI example just cited, the *life cycle innovation* portal was used with the *fund innovation* and *optimize acquisition strategy* levers, as shown in the graphic to the right.

PORTALS AND LEVERS APPLIED TO THE ARCI EXAMPLE

Portals / Levers	Science & Technology	Lab to Manufacturing	Weapon System Design	Make/Buy Decisions	Life Cycle Innovation
Fund Innovation					
Optimize Program Management/ Acquisition Strategy					
Employ External Measures					

Source: ODUSD (IP)

The three levers we will now discuss are (1) *funding innovation*, (2) *optimizing program management and acquisition strategy*, and (3) *employing external measures* as necessary. Ideally, acquisition managers make use of all participants—laboratories, academia, industry, etc.—through all phases of a program's life cycle to nurture innovation in multiple sources for the purpose of acquiring leading-edge technologies at an affordable price, as shown in the graphic below. A discussion of each of the levers and associated examples follows.



Source: ODUSD (IP)

Fund Innovation

Direct funding of innovation by the government in its science and technology (S&T) accounts and by industry in independent research and development (IRAD) accounts is paramount. During government and industry laboratory development—and the transition from the laboratory to manufacturing and later—funding alternative technologies, as well as multiple applications and suppliers, broadens the industrial base. It also improves what is available to the warfighter, often at less cost.[3] Inadequate funding for innovation can have severe consequences—hence the significance of the Department's efforts to boost science and technology funding as a critical first step to develop multiple innovative sources and technology applications.

> *"Creating market conditions attractive to business will bring you all the capacity and innovation you can use."*
>
> *– Red Team Member*

The role of contracting officers, program managers, and other acquisition professionals in translating the intent of S&T funding to induce maximum innovation is critical. Too often, the intent to develop multi-application, joint capabilities from specific critical technologies is unintentionally undermined by

> *"Competitive early development is expensive and thus avoided, but sole source efforts often cost twice original estimate anyway. We lose technologically, and don't gain programmatically."*
>
> *– Red Team Member*

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[3] In addition to classic S&T funding, other sources of innovation funding include the Defense Acquisition Challenge Program, Quick Reaction Fund, Defense Technology Transition Initiative, Advanced Concept Technology Demonstrations (ACTDs), Title III Program, Small Business Innovation Research programs, Small Business Technology Transfer programs, and Manufacturing Technology programs.

contracting actions made without strategic vision—or by programmatic decisions excessively focused on one program and its requirements. As evolutionary, broader, and more flexible acquisition tenets become increasingly important, it will be the challenge of the acquisition universities and other Department curricula to place more emphasis on the innovative paradigms so critical to 21st century warfighting. The functional area architects recommended in this study should also prove an asset to this process by constantly monitoring and comparing each other's portfolios of different capabilities and associated programs for maximum overall effectiveness. Examples that follow discuss use of the three major policy levers to source innovative technology applications.

UAV EXAMPLE

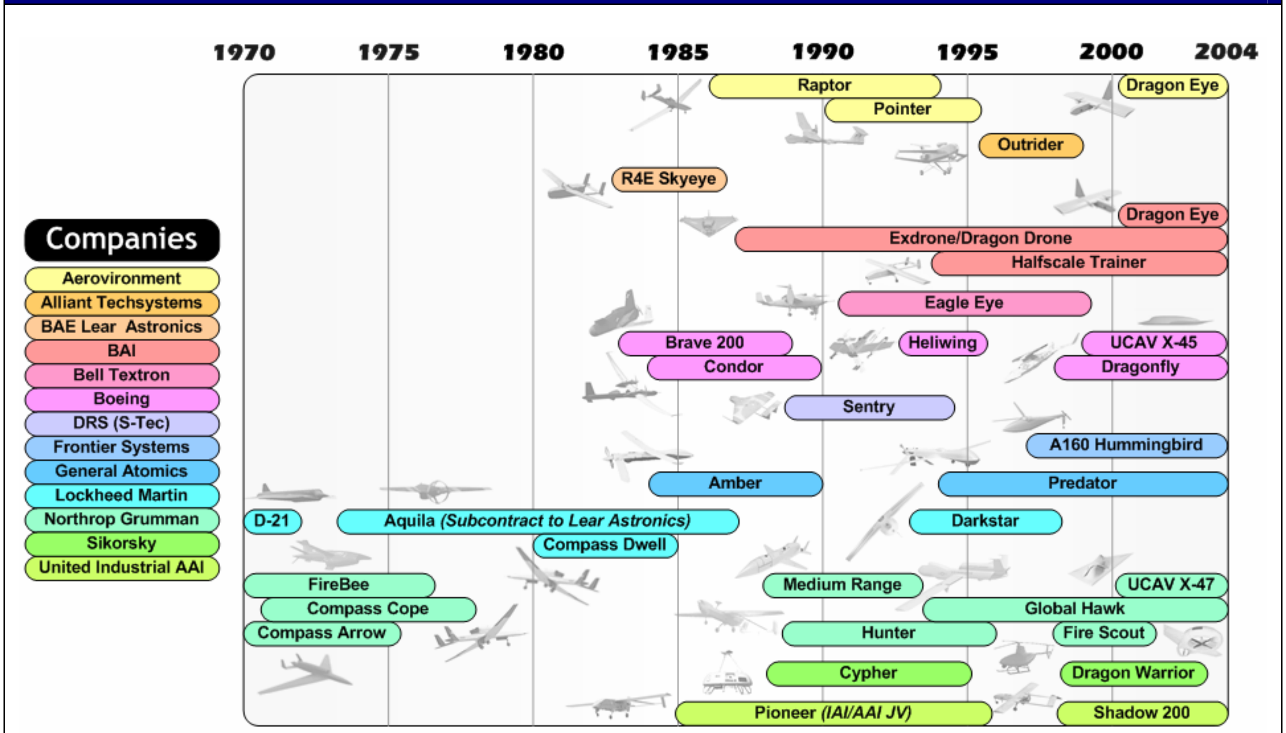
- Acquisition strategy created a single source
- Resulted in increased cost and schedule
- Represented a lost opportunity

The history of UAV development has not benefited from the hallmarks of successful aircraft development: ample funding and number of suppliers. Nor has the Department succeeded in fully migrating this extraordinary manned aircraft technology base to future unmanned applications. Consistent funding and multiple competitions enabled fighter aircraft, whose integrated sensor suites are key components of Battlespace Awareness, to become one of the most dominant warfighting capabilities of the U.S. forces from the period following World War II to the present. The United States now has a capability that assures such complete air dominance that potential adversaries generally don't dare challenge it. The Department achieved such dominance through consistent long-term funding for system innovation and through multiple competitions. In the first few decades after World War II, more than a dozen firms competed to develop and produce military aircraft. Subsequently, some firms left the business and others merged, resulting in eight remaining firms in 1990.[4] The Department nurtured innovation in military aircraft by engaging an ample number of suppliers in aircraft manufacturing over a period of more than 45 years.

Although UAVs are now almost universally identified as a critical technology, the history of their development has been marked by uneven funding due to lack of support by the Services, frequent program cancellations, and few competitions for large production contracts. As a result, no company has had the continuous activity that fosters evolutionary innovation—and the Department's progress in obtaining systems has been marked by fits and starts, impeding the development and diffusion of critical knowledge within the industrial base. The chart below illustrates the uneven nature of UAV development. Many companies over more than three decades have participated in this area—but none have had a long, continuous pattern of involvement in unmanned programs. In addition, many of these companies have exited or been subsumed in the process.

[4] Birkler, John, et. al. *Competition and Innovation in the U.S. Fixed-Wing Military Aircraft Industry*, Rand Corporation, 2003.

UAV DISJOINTED DEVELOPMENT PATTERN[5]



Source: Institute for Defense Analyses

The nature of UAV technology is such that a robust industrial base capability would be characterized as having innovative technologies with myriad applications; multiple suppliers because of low entry costs; and maximum use of COTS components or systems. The consequence of the Department's UAV procurement pattern is few deployed UAVs and a still-nascent capability in spite of the relatively long history of basic technology development. We can only guess where—and over how many applications—unmanned system innovation may have taken the Department had the history been different.

Consider, for example, the development of the Global Hawk UAV, now in high demand because of its demonstrated value in Operations Enduring Freedom and Iraqi Freedom. This is a case where the lever of funding innovation during weapon system design was intended to help maintain a competitive and innovative industrial capability. However, funding constraints led to a change in strategy and the opportunity was not realized. Global Hawk began as an Advanced Concept Technology Demonstration (ACTD) program leveraging Ryan's unmanned technology expertise going back several decades. It was selected in May 1995 from among five competing concepts. DARPA, the Global Hawk program manager, originally planned to fund two contractor teams through initial flight testing. However, budget cuts just prior to selection forced the Department to choose only a single contractor team.

[5] Affiliations in this chart reflect the companies as they exist today and not the heritage companies that may have initiated or contributed to the program.

If, on the other hand, the Department had funded multiple competing teams through initial flight test at a $160 million estimated cost for two, it would have significantly reduced: (1) performance risk because of competitive flight tests; (2) schedule risk arising from single source procurement; (3) super-optimization of one mission application and contractor approach; and (4) future acquisition costs by making available multiple sources for future competitions. This development program represented an early opportunity—not seized—to expand market demand and broaden the supplier base for a critical warfighting capability. The Department is now funding billions of dollars for UAV developments which could have blossomed earlier and at less cost—had the pressure to save $160 million not been so great in 1995.

TTNT EXAMPLE

- Acquisition strategy created innovative environment
- Source selection and management structure institutionalized this environment

Conversely, the Tactical Targeting Network Technology (TTNT) program demonstrates application of the *fund innovation* lever through the *weapon system design* portal to develop a robust and innovative supplier base. TTNT, also managed by DARPA, aims to provide the communications infrastructure to support tactical targeting from airborne platforms as part of the Joint Tactical Radio System. In early 2001, DARPA funded four large contractors to work on design requirements and four small contractors to focus on specific component technologies. In June 2002, DARPA chose one systems contractor and three small contractors to further mature TTNT technology and produce articles for testing—thereby continuing to fund multiple approaches. The Department ensured it retained ownership of TTNT intellectual property to facilitate the development of competition for subsequent phases of the program's life cycle.

From the beginning, the DARPA program manager funded a broader industrial base by soliciting industry responses for two sets of requirements: (1) total system requirements for which larger companies were better suited; and (2) component requirements that small companies with emerging technologies could best satisfy. DARPA funded an industrial base for this program of four system and four component suppliers in the preliminary design phase, reduced it to one system and three component suppliers a year later for the maturation of TTNT technology; and in the future production phase, will be able to attract more suppliers because of the Department's predominant ownership of the intellectual property, thereby allowing for expansion of the defense industrial base—if required.

Optimize Program Management and Acquisition Strategy

Over the years, the Department and its prime contractors have developed and employed a myriad of program management structures and acquisition strategies

primarily to optimize program cost, schedule, and performance—sometimes not considering the full impact of such structures and strategies on the industrial base. However, as the following examples illustrate, organizational structures and acquisition strategies can have a significant impact on the Department's ability to acquire multiple innovative sources to maintain technology leadership. Acquisition programs are at the front lines of shaping the defense industrial base. Tactics at the program-level must be consistent with the Department's strategies to develop sufficient industrial base capabilities, incentivize industry to be innovative, and to seek multi-application solutions.

> *"Robust competition to meet challenging performance goals is the most consistent source of innovation."*
>
> *- Red Team Member*

Government and industry program management structures, as well as acquisition strategies, can provide positive or negative impacts on the numbers of suppliers and sources of innovation. For example, government management structures can encourage the development of multiple suppliers. On the other hand, as discussed below, if they allow too narrow a focus on Service-specific applications with the prime contractor and its sub-contractors, they can work to discourage other contractors from contributing competing innovative technologies. Likewise, industry management structures can positively impact innovation. For example, partnering with competitors for contracts in specific program areas where there are few contract awards and limited funding can produce innovative synergies. In some instances, however, partnering can result in monopolistic behavior that works to exclude competitors and squelch innovation. Finally, acquisition strategies may impact innovation either positively or negatively. A strategy where the Department funds multiple sources in early technology development, for example, nourishes the growth of multiple, innovative sources. A strategy where contractors have too much responsibility for program development and inadequate government oversight may foster dependence on current suppliers to the exclusion of other sources of innovative solutions.

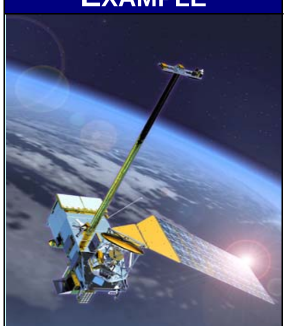
Traditional program cost, schedule and performance goals also can defeat program managers trying to apply strategies necessary to obtain the innovative technology the Department requires. The dynamic nature of program development and budget decisions can force changes in acquisition strategies to the detriment of broader industrial base considerations.

A case of program management structure masking industrial base problems is illustrated in Space-Based Infrared System-High (SBIRS-High). Here is a case where the o*ptimize program management structure and acquisition strategy* lever was not employed during weapon system design. The program office was structured to provide minimum management oversight of the contract using a total systems performance responsibility (TSPR) clause. Major problems of cost, schedule, and performance in SBIRS-High surfaced in late 2001 in part due to the inability of industry to produce key capabilities because of problems related to lack of maturity in the system design.[6] These problems forced both government and contractor program offices to be restructured. The Department's review of the program at that time identified government program office structural issues, government and contractor program management turnover, and the TSPR acquisition strategy collectively as major contributors to the program's problems. The recovery plan is attempting to correct these issues with a restructured contract and management team. This experience reminds the Department of the risks of inadequate program oversight. Lack of attention to the impact of management structure and acquisition strategy on program performance set the stage for program failure, and this program continues to struggle to recover.

SBIRS EXAMPLE

- Government program office structure proved to be inefficient in controlling cost, schedule and performance
- Required restructuring of government and contractor management teams
- Restructured contract to bring performance and technology into line

NPOESS EXAMPLE



- Program merger resulted in consolidation of competitive opportunities
- Acquisition strategy maintained robust competitive environment for innovative industrial capabilities

The combination of the military Defense Meteorological Support Program (DMSP) and the civil Polar-orbiting Operational Environmental Satellites (POES) saved significant money but risked reducing the opportunities for competition in a very innovative set of industrial capabilities. To address these risks, the integrated program office (IPO) for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) addressed this impact to the industrial base through application of the *acquisition strategy* and *fund innovation* levers through the *weapon system design* portal. The merger did not change the number of satellites to be procured but did reduce the number of distinct satellite design opportunities from two to one. The resulting program was estimated to produce sizable cost savings of over $1.6 billion through 2018 by reducing redundancies in U.S. meteorological satellite systems. To avoid reducing the innovation in the industrial base along with the costs, the IPO employed acquisition strategies to

[6] Other causes cited during Nunn-McCurdy breach deliberations included lack of effective requirements and system engineering, and a breakdown in execution management within both Government and contractor teams.

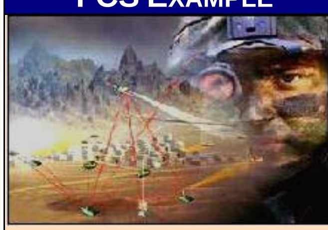
create a robust competitive environment by directing competitive subcontracts in the key sensor technologies. Losers of the sensor design competitions were allowed to team with the winners to leverage their best collaborative design and production capabilities, and stay engaged in one of the few major space-based remote sensing programs.

Using the *management structure/acquisition strategy* lever to ensure multiple innovative sources will be even more challenging for future programs. As network-centric warfare demands synergies among defense systems, we are reminded that management structures and acquisition strategies must adapt to ensure the industrial base is properly incentivized to innovate key technologies—across multiple applications or missions. The E-10A Multi-Sensor Command and Control Aircraft program is an example of how the needs to replace several platforms can be met with a distinctive organization and acquisition strategy. The E-10A program employs a cluster of program offices within a lead program office, reinforcing common technologies and systems among the cluster's elements. The program's acquisition strategy is a hybrid as well. It has sole source system integration and platform contractors where the benefits of innovation and competition have already been garnered. However, where innovative technologies can provide critical capabilities, such as in the Battle Management Command and Control System, competition is preserved.

E-10A EXAMPLE

- Innovative management structure
- Competition-based acquisition strategy
- Results in an innovative industrial base for future competitions

FCS EXAMPLE



- Innovative management structure has potential to generate competitive industrial base environment
- Lack of government oversight and over-reliance on industry as an LSI may have unintended negative consequences

The Future Combat System (FCS) offers an example of an innovative management structure and acquisition strategy approach designed for an extremely complex and massive network-centric program critical to the Department's 21st century warfighting needs. It is using the *management structures/acquisition strategy* lever through the *weapon system design* portal to gain access to system-of-systems and network-centric capabilities found in the larger prime contractors and system engineering houses while retaining full access to the rest of the industrial base to provide critical capabilities in the systems and components that make up FCS. The Army has selected a strategy that establishes a contractor lead system integrator (LSI)—the Boeing/SAIC team—that works closely with the government program office. SAIC and Boeing play a major role in establishing program standards and selecting component contractors. They manage the identification, selection, and procurement of the major FCS systems and subsystems, with the explicit challenge and mandate not to self-deal.

However, while it is too early to know for sure, the FCS LSI approach may not provide the government the necessary in-depth understanding of that program's impact on the industrial base, particularly for the application of innovative technologies developed in FCS for non-Army applications. Based on its experience with TSPR, the Department has expressed unease with such heavy reliance on a contractor team for key program decisions, especially faced with high Department program office turnover rates. Thus, it is critical that the Department maintain insight into the LSI contractor processes and procedures of this program to ensure that they satisfy industrial base outcomes. In FCS, the contract requirement that the Army Acquisition Executive review all decisions in the *make or buy* portal should help to mitigate this risk.

As these examples have illustrated, deploying the portals and levers in the construct we have developed differs for each situation. Developing a new technology or addressing an industrial base deficiency will require a solution crafted specifically for that deficiency. In making decisions, from resource allocation to acquisition strategies, the Department must ensure that the industrial base and strategies to ensure its sufficiency be considered—particularly in cases involving critical and multi-application technologies.

> *"The ability of acquisition managers to do this effectively depends on whether they continue to manage individual programs, which forces a parochial view, or a capability or technology area, which would cause them to optimize for that broader capability or technology area—a structural issue."*
>
> *– Red Team Member*

The future will demand great finesse in the application of the *program management/ acquisition strategy* lever if the Department is to synergize available industrial base capabilities across broad applications. It is for this reason that we recommend establishing the functional area architect and conducting industrial base assessments for critical capabilities throughout the program life cycle. With the functional architects in all acquisition board meetings to monitor acquisition strategies and elevate industrial base concerns, these reviews will become more effective in maximizing innovation to the benefit of warfighting capabilities—and the defense industrial base.

Changing warfare strategies must erode the familiar platform-centric patterns the Department has long used to structure its thinking, but will only do so in the measure that acquisition professionals view themselves as stewards of warfighting capabilities and not owners of stovepipe platforms. The rest of the Department is adapting to these changes in order to create acquisition processes that recognize the power of synergizing capabilities across Services and platforms. Even our historical platform-based milestone approval process is now undergoing revision to focus on gaps and overlaps in capabilities provided by systems, rather than on the discrete systems themselves. Acquisition strategies are already beginning to bear the imprint of the portals and levers construct to

challenge program managers to develop plans for innovation and innovative uses of their technologies—throughout program life cycles.

Employ External Measures

Previously we discussed two levers available to program managers to develop multiple sources of innovative technologies that can potentially be used to enhance multiple warfighting capabilities: *funding innovation* and *optimizing program management structures and acquisition strategies*. While these tools traditionally may be used to solve cost and technical quality problems, another important purpose is to ensure the development and sustainment of critical and innovative industrial base capabilities.

Now we will discuss measures external to the normal life cycle development of a program that the Department employs on an ongoing basis but also can employ when the first two levers do not secure sufficient innovation for critical capabilities. This third lever includes collaborating with other agencies to apply regulatory remedies in order to prevent undesired foreclosure of competition or innovation.

The graphic below depicts the seven "external" corrective measures available to the Department to remedy or prevent undesired effects on the industrial base. Three of them are external to individual programs, but internal to the Department. While the four on the right side of the chart are external to the Department, the Department has significant influence as to how these tools are employed.

EXTERNAL MEASURES			
DoD		Interagency	
Measure	**Purpose**	**Measure**	**Purpose**
Stage competitions to add sources	Induce innovation. Major risk reduction for too few/failing source(s) or lack of performance	Hart-Scott-Rodino Remedies	Maintain sufficient number of competitive sources
		Exon-Florio Remedies	Maintain technology leadership and security of supply but allow foreign direct investment
Restructure Management Approach	Eliminate excessive self-dealing or narrow focus on specific issues or applications	Balanced Export Controls	Keep military technology from adversaries but allow competition in global markets
Block Teaming Agreement	Discourage fusion of innovation into single source; prevent cartel-like behavior	Foreign Cooperative Agreements	Help develop and access foreign sources where appropriate
Source: ODUSD (IP)			

Funding permitting, the Department can stage competitions to add sources in order to induce innovation and improved performance, while reducing risk. When innovation is desired, competitions must avoid contract clauses and acquisition strategies that encourage risk-averse behavior and drive out innovation. The

Department also can restructure its management approaches, as was done in the case of the SBIRS-High program discussed earlier, to preclude excessive in-house sourcing or premature narrowing of technology focus. As will be discussed in the case of DD21/DDX, the Department can block teaming arrangements in order to prevent combinations that would result in single sources and thereby restrict the competitive pressures that drive innovation. The Department can, and does, use these tools to ensure program management decisions do not lead to unintended consequences.

The Department also uses interagency processes to influence competition and innovation while protecting national security. Using the deliberative process established by the Hart-Scott-Rodino Antitrust Improvement Act, the Department works with the Department of Justice (DoJ) and Federal Trade Commission (FTC) to block proposed business combinations when necessary to preserve competition or for other reasons of national security. The Exon-Florio Amendment to the Omnibus Trade and Competitiveness Act authorizes the President to suspend or block foreign acquisitions, mergers, or takeovers of firms located in the United States when they pose credible threats to national security by transferring key industrial capabilities. The Department participates in an interagency committee, chaired by the Department of the Treasury to exercise the Department's leadership prerogative. Similarly, the Department of Defense works with the Department of State on export controls. Export controls should be structured to keep key, critical military technology from our adversaries, yet allow domestic firms to compete in international markets to preserve their global competitiveness.[7] Foreign Cooperative Agreements are agreements between the Department of Defense and foreign governments that allow the Department to develop and access foreign technologies and products that offer unique warfighting benefits.

DoD Measures

The Department has various corrective measures it can apply in order to preserve a robust, innovative industrial base when such action is necessary. First of all, it can take measures to induce innovation by staging competitions to add sources. Over the years, the Department sometimes has been forced to induce innovation within high risk programs or programs that have shown a decline in performance. Techniques range from developing alternative sources, such as in the case of the Navy's ARCI program, to developing technology insertion processes such as practiced today with spiral development planning.

[7] Northrop Grumman's development of the APG-68(V)9 radar for sale to the United Arab Emirates and Singapore helped bring forward technologies and mitigate risk on 4th generation radars for both the F-22 and JSF programs. The foreign investment helped to lower non-recurring engineering costs and to transfer technology and manufacturing advances to production. This demonstrates how "the international market" benefits the Department.

The goal always has been to find the best technology and ideas so that program offices can source the broadest array of solutions available.

Another measure the Department sometimes employs is to restructure its management approach. As was discussed earlier, when the SBIRS-High program was experiencing significant problems in late 2001, the Department took action to restructure management oversight to ensure the maturation of innovative technologies inherent in the program, among other corrective measures. The formation of joint program offices within the Department is often used to create a management structure to accelerate the development of innovation and the preservation of competitive sources. Examples of this are the Missile Defense Agency and the recent stand-up of the Joint Unmanned Combat Air Systems program office at DARPA.

A third measure that the Department occasionally employs is to block teaming arrangements. Teaming relationships sometimes can effectively reduce the number of suppliers in a given market, especially if the two firms teaming are dominant in a particular market sector. On some occasions, it becomes necessary for the Department to interject itself to avoid, or even break up, teaming arrangements between companies in order to sustain competitive conditions and nurture innovation.

One notable example of the Department wielding the *employ external measures* lever occurred in 1998, when the two existing Navy combatant shipbuilders, Ingalls and Bath Iron Works, and the Navy's only large ship combat system supplier/integrator, Lockheed-Martin, announced they would team to bid for the Navy's new DD21 surface combatant ship design and construction program. To motivate continued improvement in key industrial capabilities, the Navy developed and implemented a revised acquisition strategy prohibiting Ingalls/Bath Iron Works and Lockheed-Martin from participating as a team. Thus, for the DDX competition, the two shipyards formed separate teams, promoting the development of distinctive capabilities and alternative sources in a critical industrial sector.

DDX EXAMPLE

- Industry teaming threatened access to innovation
- Acquisition strategy revised to ensure competitive sources

Interagency Measures

There are also measures the Department can employ in collaboration with government regulatory bodies outside the Department. The Hart-Scott-Rodino (H-S-R) legislation provides the basis for the Department's review of the impact of proposed acquisitions or mergers on innovation and competition in the industrial base. Working closely with anti-trust authorities, the DoJ and the FTC, the Department is able to block mergers or, if necessary, secure judgments that force restrictions on the acquiring firm in order to preserve competition in key

technologies for critical capabilities. Finally, the Department, in conjunction with the Department of Treasury and the Department of State, can prevent the transfer of critical technologies through Exon-Florio remedies and export control laws, respectively. On the other hand, DoD can also negotiate Foreign Cooperative Agreements to fund and access critical technologies, especially where the source for a critical capability is foreign.

H-S-R Adjudication

The Department's role in Hart-Scott-Rodino (H-S-R) assessments is to look at the implications of a transaction on future competition and innovation. This prospective look is particularly critical as revisiting a merger after the fact is only permitted if the offending issue was not foreseeable at the time of the review.

Raytheon's recent acquisition of Solypsis highlights a situation in which the Department proactively worked with the DoJ to preserve competition in technologies critical to its network-centric warfighting plans. The Cooperative Engagement Capability (CEC) will integrate battle force combat systems and sensors into a single, force-wide, distributed combat system in order to counter increasingly capable and less detectable cruise and tactical ballistic missiles.

RAYTHEON – SOLIPSYS EXAMPLE

Raytheon | SOLIPSYS

- Proposed merger of two sensor netting companies
- Transaction allowed with agreement to offer capability to competitors
- Remedy preserved competition for future while enhancing the development of advanced capabilities

Recently, as the CEC Block II competition moved forward, Raytheon decided to acquire Solipsys, a firm with the only other sensor netting product thought to be technically mature enough to represent a viable alternative to the unique CEC hardware and software design: the Tactical Component Network (TCN). Recognizing the implications of this transaction, the Department used the *employ external measures* lever and, with the DoJ, insisted that Raytheon sign a letter of agreement to offer the Solipsys TCN as a merchant supplier to other contractors for future solicitations. By exercising this lever, the Department preserved the possibility of competition for future defense applications. As the example illustrates, the Department works with the antitrust regulatory agencies on a forward-looking basis to ensure a healthy, competitive industrial base for critical capabilities and applications.

LOCKHEED - NORTHROP EXAMPLE

- Proposed merger of two AEW radar providers and platform integrators
- Transaction denied
- Preserved competition in AESA market

The Department also recommended antitrust regulatory actions to preserve innovation and competition in airborne active electronically scanned array (AESA) radar technologies critical to battlespace awareness. One of the defining moments for the airborne AESA industry occurred as a result of Lockheed Martin's attempt to buy Northrop Grumman in 1997. The Department and the DoJ reviewed the merger and filed suit to block it in March 1998, citing potential horizontal and vertical integration issues regarding airborne early warning (AEW) radar along with the loss of competition and innovation in a number of critical systems and components. At the time of the merger, Lockheed and Northrop Grumman were the only two U.S. AEW radar providers. Only two companies (Raytheon and Northrop Grumman) had experience integrating AESA fire control radars in fighter aircraft. After the merger, Lockheed Martin would have had significant vertical AEW and AESA capabilities and could have foreclosed opportunities to potential radar competitors or denied radars to other aircraft competitors. By blocking the merger, the Department and the DoJ preserved competition in the airborne AESA industry, paving the way for its innovation and application to myriad non-airborne applications.

NORTHROP – TRW EXAMPLE

- Proposed merger of satellite prime and subsystem provider
- Transaction allowed with consent decree providing for systems prime impartiality and requirement to provide payloads to competitors
- Department's Compliance Officer to oversee make/buy and merchant supplier provisions
- Remedies preserve competition; competitors not foreclosed from legacy TRW payloads and components

With Northrop Grumman's acquisition of TRW, the Department also took measures to ensure multiple competitive sources in the critical reconnaissance satellite systems sector. After thorough analyses of the effects of the proposed acquisition, the Department communicated its concerns to the DoJ which in turn negotiated a consent decree, forcing Northrop Grumman to select payloads on a competitive and non-discriminatory basis and to provide legacy TRW technology to other competitors.

> *"By requiring Northrop to make its sophisticated satellite payloads available to competitors, along with other provisions, this consent decree enables the U.S. government—the only customer of reconnaissance satellites—to continue to benefit from competitive prices, higher quality, and continued innovation."*
>
> – *R. Hewitt Pate, Acting Assistant Attorney General, Antitrust Division, DoJ, December 11, 2002*

Although discussed earlier as a measure the Department can use internally, blocking teaming relationships also is an action that the Department sometimes takes in conjunction with the DoJ when such teamings have the potential to adversely affect competition and thus negatively impact innovation.

The teaming relationship between DRS Technologies and Raytheon for electro-optical systems using second generation forward looking infrared technology is illustrative of a situation that required the attention of the Department and the DoJ. The Department decided to allow teaming on current contracts since the benefits of competition had already been garnered, given the phase of development of the related acquisition programs. However, the Department indicated that teaming for future programs (e.g., the Advanced Amphibious Assault Vehicle) would be unacceptable because of the negative effect on competition. The regulatory review resulted in both firms modifying their teaming agreement accordingly.

DRS - RAYTHEON EXAMPLE

- Proposed team of the only two second generation FLIR suppliers
- Teaming allowed for existing contracts; not for future competitions
- Modification of teaming agreement retains competition for future while realizing savings on current contracts

When corporate mergers or teaming agreements significantly reduce the competitive pressures which drive innovation, the Department must be prepared to use regulatory powers. In such situations, H-S-R adjudications provide the Department a means to maintain competition and induce innovation for industrial and technological capabilities critical to the warfighter.

Exon-Florio Remedies, Export Control, and Foreign Cooperative Agreements.

The Exon-Florio Amendment to the Omnibus Trade and Competitiveness Act of 1988 amended the Defense Production Act to authorize the President to suspend or block foreign acquisitions, mergers, or takeovers of U.S. firms when credible threats to national security cannot be resolved through other provisions of law. The President has delegated management of the Exon-Florio Amendment to the interagency Committee on Foreign Investment in the United States (CFIUS), chaired by the Department of the Treasury. Within the CFIUS, the Department of Defense determines if the company or business unit being acquired possesses critical defense technology under development or is otherwise important to the defense industrial and technology base.[8]

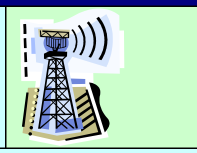
Critical technologies and capabilities highlighted by the DIBCS will be important decision aids for the Department in this process. In cases where the Department believes the technologies and capabilities are leading-edge and unavailable to potential adversaries, it may choose not to allow companies with these capabilities to be acquired by foreign companies, or it may develop remedies to reduce the risks of unauthorized technology transfer. In this manner, the Department actively works to safeguard critical defense technologies.

The Department also can advocate export control restrictions to the Department of State when U.S. companies desire to export critical technologies or

[8] For further information on the HSR and CFIUS processes, refer to the ODUSD(IP) *Business Combinations Deskbook* posted at http://www.acq.osd.mil/ip.

capabilities abroad. Conversely, where a sole source of a critical capability may be foreign, it may be advisable to engage in cooperative agreements with the company's government to ensure adequate funding to shape the endeavor.

CATALYST II EXAMPLE



- Combined U.K. and U.S. EW systems with U.K. software
- Saved $5-8 million and 2-3 years development time and increased commonality with major ally

In the case of the Catalyst II program, the Department sought more robust electronic warfare (EW) capabilities through the integration of a United Kingdom system, Soothsayer, with a U.S. system, Prophet. Each is an EW system focusing on upgrades to electronic support, electronic attack, and precision location systems. For this new application, the United States also acquired SAGE software from the United Kingdom with a state-of-the-art capability to detect, classify, and locate modern battlefield communications signals. The combined Catalyst II program saved between $5-8 million and two to three years of development time.

In summary, the portals and levers approach is a valuable tool to enhance the health of the defense industrial base. Portals encourage systematic examination of management decisions throughout the technology and program life cycles. Levers provide the means to ensure the innovation and investment that will keep the United States ahead of foreign competition for critical industrial base capabilities. Along with the levers available to programs, external measures within the Department and with the cooperation of regulatory agencies are available to retain innovation and remedy deficiencies. The Department must lead by example in applying new functional capability-based thinking, management practices, and behavior.

APPENDIX E

PROGRAM MANAGEMENT AND ACQUISITION STRATEGY TAXOMONY

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PROGRAM MANAGEMENT AND ACQUISITION STRATEGY TAXONOMY

The functional capability construct requires increased emphasis on program managers' ability to deliver critical capabilities to the warfighter that leverage technology advances. The Department's acquisition policies have not stood still in the face of change. Programs have adapted "on the fly" and thus become guideposts for changes. Newer programs have taken advantage of their greenfield opportunity by creating entirely new constructs. The acquisition community has taken concepts unknown in 1980 and made them commonplace, giving us new tools as we move forward—and will continue to do so.

Program managers must have a robust set of acquisition tools with which to work, and they must use these tools flexibly, tailoring them to their changing requirements. To assess these capabilities, we examined Force Application programs from two perspectives. First, we compared the way a sample set of programs were using program management and acquisition strategy (PM/AS) tools. Second, we studied a smaller group of programs to see how they have successfully used the available tools to adapt to changing circumstances.

We first listed the acquisition initiatives available to program managers (as shown on the vertical axis of the spreadsheet shown on pages E-6 and E-7) and determined which were used by each program. This survey was designed to tell us whether the newer acquisition tools were widely applied, and whether programs were demonstrating flexibility by using different tools to match unique circumstances.

The survey showed that program managers in the Force Application sector are indeed making flexible use of the tools provided to them, and that this bodes well for these and future programs as they begin to operate in the functional capability context. Some techniques, such as Low Rate Initial Production (LRIP), are used by nearly every program. LRIP offers the opportunity to maintain flexibility before moving to full production—effectively keeping the weapon system design portal open—allowing programs to incorporate the latest technology, respond to changing warfighter requirements, and synchronize with other programs within their functional capability sector.

Spiral development, though not yet universally applied, is also widely utilized. The Army is particularly forward leaning here, applying spiral development to five of the six programs we surveyed. Like LRIP, spiral development can maintain flexibility, and has the effect of keeping portals open so that programs can adapt later in their acquisition process. Like the flexibility of LRIP, this will be critical as programs begin to operate in the dynamic functional capability environment.

Several programs reported use of the Lead System Integrator (LSI) concept, even though the Future Combat System (FCS) is best known as the innovator in this area. This reminds us that, although FCS applies the concept on a larger scale than any previous program, LSI is in some ways an extension of what prime contractors have always done in integrating the myriad subsystems that make up complex systems such as tactical aircraft, aircraft carriers, and submarines. In our new environment, the broader application of LSI will allow wide company participation in technology insertion, capability development, and system-of-systems architecture, improving our ability to provide the capabilities our warfighters require.

To ensure prime contractors do not shut out innovative subcontractors in favor of doing the work in-house, the USD(AT&L) has signed policy guidance[1] to program managers and contracting officers to retain both insight into the subcontractor selection process and an ability to influence that selection. For example, when establishing the contract fee structure, program managers and contracting officers are being encouraged to give more value to the contractor's effective use of competition throughout the life of the program. In fact, the program manager may require that certain subcontracts be let only after explicit DoD approval if there is determined to be bias in selection of a subcontractor and the potential bias cannot be adequately mitigated.

Our survey also showed that program managers are scanning the available acquisition tools and choosing the ones useful to them, tailoring a toolbox that works for their programs. Prototyping, for example, is a useful way to test and verify new concepts, but is more practical for tactical missiles than for ships. Consequently, we see the Army using prototyping on four of the six programs we surveyed, while the Navy limits prototyping to the subsystem level. Similarly, Advanced Concept Technology Demonstrators are an excellent way to get capability quickly, as we have seen with Predator and with Global Hawk. But ACTDs can increase risk as they push new technology to the warfighter, and are most practical for systems with smaller unit costs, where the required investments are smaller, and the risk/reward ratios are more favorable. We wouldn't expect to see wide application of ACTDs to the large unit cost/small quantity systems in this group, such as ships, and we don't. Instead, we see the concept applied to the smaller Land Warrior and High Mobility Artillery Rocket System (HIMARS) and the Tomahawk warhead.

Overall, our survey showed that program managers are applying the *program management* lever[2] through flexible use of acquisition strategies. This will allow powerful portals to remain open for a greater portion of the acquisition process, as they must if we are to have an acquisition system that is adaptable and

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[1] Wynne, Michael W., Memorandum for Secretaries of the Military Departments, Service Acquisition Executives, and Directors of Defense Agencies. 12 July 2004.
[2] See Appendix D for discussion of Policy Portals and Levers.

responsive to functional capability requirements. Our complete taxonomy follows.

			AIM7	AIM-9M	MM-III	Longbow Hellfire	B-2	AMRAAM	AGM-88E	F22	F/A-18	Land Warrior	Tomahawk
PROGRAM MANAGEMENT	GOVERNMENT	Single Service Program Office	Yes	Yes	Yes	Yes (Army)	Yes (USAF)	No	No	Yes (USAF)	Yes	Yes (Army)	Yes
		Lead Service Program Office											
		Joint Program Office	No	Yes	No	Partial	No	Yes	Yes	No	No	Interest	No*
		Multinational Program Office	Yes	No	No	No	No	Yes		No	No	Interest	No
		Defense Agency Mgmt	No	No	No	No	No	No	No	No	No		No
		Government Integrated Product Teams	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes		Yes
		Government/ Industry IPTs									Yes	Yes	
		Government-Contractor Collocation	No	No	No*	No		No	No	No	No	Yes	No
	INDUSTRY	Single Prime Contractor	No	Yes*	Yes		Yes	Yes*	Yes	No	No	Yes	No
		Contractor Teaming	Yes	History?	No	No	No	No		Yes	Yes		Yes
		Joint Venture	Yes*	No	Subs	Yes	No	No		No	No	No	No
		National Team	No	No	No	No	No	No		Yes	No	No	No
		Non-Traditional Subcontractor	No	No	No	No	No	No	No	No	No	Sub-sub	No
		Foreign Subcontractor	Yes*	No	No	No	No	Yes	Yes	Yes	Yes	Sub-sub	Yes

			AIM7	AIM-9M	MM-III	Longbow Hellfire	B-2	AMRAAM	AGM-88E	F22	F/A-18	Land Warrior	Tomahawk
ACQUISITION STRATEGY	Pre SDD	Prototyping	N/A		No	Black	No	no	Yes	Yes	No	Yes	
		ACTD	No	No	No	No	No	no	No	No	No	Yes	Yes*
	Milestone B to LRIP	Delegated MDA		n/a	Yes		No	Yes	No	No	No		
		Pilot or Flagship	No	No	No	No	No	Yes	No	No	No	Yes	No
		Integration by Government		History	No	yes	No	No		No		Yes	No
		Lead System Integrator	No	No	No	No	No	No	Yes	No	Boeing		No
		High Dev Cost Incentive			CPIF	No			Yes				Yes
		Producibility Incentive in Dev Contract	N/A			No		Yes	Yes				Yes
	LRIP to SUSTAINMENT	Spiral Dev	No	No	No	No	No	Yes	Yes	Yes	No	Yes	Yes
		LRIP Planned	Yes		Yes	yes	No	Yes	Yes	yes	Yes	Yes	Yes
		Leader Follower Competition in Production	Yes	No	No	no	No	Yes	Yes	No		No	Yes
		> 1 Production Source Planned, Implemented		History	No	no	No	Yes		yes - subs		No	Yes
		Production Cost Incentive			FPIF	firm fixed price	Award Fee (target price curve), FFP Production Contract, CPAR's, Producibility Im						Yes
		MYP Planned	no	No	No	yes	No	No	TBD	Yes	Yes	Possible	
		Foreign Military Sales Planned	Yes	Yes	No	yes	No	Yes	Yes	No		No	Yes
		Production Rate Variation	no		Yes	not significant	Yes		Yes	Yes	Yes		Yes
		Total System Performance Responsibility	No	No		No		Yes	No	No	No		No
		Contractor Logistics Support Planned	Yes	No	No	No		Yes	No	No			No

			Javelin	B-1 upgrade	JSF	SSN-774	Excalibur	JASSM	JDAM	Stryker	HIMARS	LCS
PROGRAM MANAGEMENT	GOVERNMENT	Single Service Program Office	No	Yes	No	Yes (Navy)	Yes (Army)	Yes (USAF)		Yes	Yes (Army)	Yes, Navy
		Lead Service Program Office							Air Force			
		Joint Program Office	Yes	No	Yes	No	Army Navy to increase commonality with Navy ERGM	Yes	Air Force/Navy		No*	Yes
		Multinational Program Office	No	No	Yes	No		No			No	No
		Defense Agency Mgmt	No	No	No	No		No		No	No	No
		Government Integrated Product Teams			Yes			Yes				No
		Government/ Industry IPTs								Yes		Yes
		Government-Contractor Collocation	No	No	Yes			No		No	Yes	Yes
	INDUSTRY	Single Prime Contractor	No	No	No	No	No	Yes	Yes	Yes	Yes	No
		Contractor Teaming	No	Yes	Yes	Yes	Yes	No			No	Yes
		Joint Venture	Yes	No	No	No	No	No		Initially	No	No
		National Team	No	No	No	No	No	No			No	No
		Non-Traditional Subcontractor	No	No	No	No		Yes		No	No	Yes
		Foreign Subcontractor	Yes	No	Yes	No	Yes	No		Yes	Yes	No
			Javelin	B-1 upgrade	JSF	SSN-774	Excalibur	JASSM	JDAM	Stryker	HIMARS	LCS
ACQUISITION STRATEGY	Pre SDD	Prototyping	Yes	No	JAST	yes		No		Yes		Yes
		ACTD	No	no	No			No		No	Yes	No
	Milestone B to LRIP	Delegated MDA	Yes	Yes	No			Yes		No		No
		Pilot or Flagship	No	no	Yes	Yes		No		No	Yes	No
		Integration by Government	No		No			No	No			Yes
		Lead System Integrator	No	No	No			No	Yes	No	Yes	N/A
		High Dev Cost Incentive	CPIF	award fees	CPIF							Yes
		Producibility Incentive in Dev Contract	No						Yes			Yes
	LRIP to SUSTAINMENT	Spiral Dev	Yes	Yes	No*		Yes	No*		Yes	Yes	Yes
		LRIP Planned	Yes	Yes	Yes			Yes	Yes	Yes	Yes	No
		Leader Follower Competition in Production	No	No	No		For IMU	No	No	No	Yes	No
		> 1 Production Source Planned, Implemented	No	No	Risk Mitigation		Subs	No	No			Yes
		Production Cost Incentive	FFP					Commercial		Yes	Yes	Yes
		MYP Planned	Yes	no	TBD			No		No	No	Yes
		Foreign Military Sales Planned	Yes	No	Yes	No	No	No		No	Yes	No
		Production Rate Variation		no	N/A	Yes		No		No		No
		Total System Performance Responsibility	No		Insight vs. Oversight			Yes	s (20 year warran	No	Yes	No
		Contractor Logistics Support Planned	Yes		TBD			Yes		No	Yes	N/A

Program Management and Acquisition Strategy Taxonomy Glossary:

>1 Production Source Planned, Implemented: More than one production source exists.

ACTD: Advanced concept technology demonstrations exploit mature advanced technologies to solve important military problems. Often managed by DARPA or other agency, and characterized by minimal specifications regulation.

Contractor Logistics Support Planned: The program includes plans for logistics support following delivery of the product.

Contractor Teaming: Two or more contractors are formally teamed by memorandum of understanding or other agreement, but do not form a financial entity to execute a program.

Defense Agency Management: A defense agency outside of OSD manages the program.

Delegated MDA: Milestone Decision Authority for ACAT 1 program has been delegated by USD(AT&L), to the head of a DoD Component. The delegated MDA reviews each technology project or acquisition program as informed by the IPT process, and the independent assessments required by law or the MDA's judgment.

Foreign Military Sales Planned: The program includes plans to sell to foreign military services.

Foreign Subcontractor: The program team consists of one or more significant foreign sub-contractors.

Government Integrated Product Teams: Groups of government specialists from different areas and organizations that are assembled to address specific tasks.

Government/ Industry IPTs: Groups of government and industry specialists from different areas and organizations that are assembled to address specific tasks.

Government-Contractor Collocation: Government and contractor share a physical location.

High Dev Cost Incentive: Government gives the contractor incentives to lower the development costs.

Integration by Government: Government handles the integration of the elements of the program.

Joint Program Office: The program office is managed under a formal agreement including two or more services.

Joint Venture: Two or more contractors create a legal entity that is distinct from either of the partners.

Lead Service Program Office: More than one service procures the system, but one service manages the acquisition.

Lead System Integrator: The lead contractor handles the integration of the elements of the program.

Leader Follower Competition in Production: The leader must make production information available to the follower.

LRIP Planned: Low rate initial production.

Multinational Program Office: Two or more entities, at least one of which is foreign, actively participate in program management in the same office.

MYP Planned: Plans for production span more than the conventional two years.

National Team: A team of contractors assembled following directives from DoD.

Non-Traditional Subcontractor: A sub-contractor that has not previously significantly participated in DoD contracts.

Pilot or Flagship: Programs designated by OSD or Service acquisition executives as programs demonstrating innovative and/or improved acquisition processes.

Producibility Incentive in Dev Contract: Government gives the contractor incentives to ensure producibility of the product.

Production Cost Incentive: Government provides incentives to lower production costs.

Production Rate Variation: Over the course of the program, the production rate has varied, possibly leading to difficulties.

Prototyping: The program team builds one or more prototypes as part of the development process.

Single Prime Contractor: Traditional contracting relationship.

Single Service Program Office: The acquisition program is managed by a single Service.

Spiral Dev: Desired capability is identified, but the end-state requirements are not known at program initiation. Those requirements are refined through demonstration

and risk management; there is continuous user feedback; and each increment provides the user the best possible capability. The requirements for future increments depend on feedback from users and technology maturation.

Total System Performance Responsibility: The responsibility of the prime contractor includes total system performance.

APPENDIX F

A TAXONOMY OF DOD TECHNOLOGY DEVELOPMENT AND TRANSITION INITIATIVES AND FUNCTIONS

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A Taxonomy of Selected DoD Technology Development and Transition Initiatives and Functions

There are myriad programs and mechanisms within DoD for the development and transition of technology. The chart below highlights several of these and generally characterizes them in the dimensions described above.[1] Although none of these programs or activities is chartered to perform exactly the same function, they often serve similar functions, and more often, work toward similar ends.

The survey reveals that no single program does the job envisioned by the Industrial Base Investment Fund. Notably, there is a dearth of programs with a cross-service, capability-based span of awareness with focus on delivering producible solutions through programs of record assuring broadest possible dissemination of innovative technologies across all warfighting applications.

Technology Development and Transition Initiatives

Initiative	Advocacy	Customer Orientation	Span of Awareness	Funding	Innovation Portal	Technology Scope	Function	Primary Marketplace
	Joint/OSD	PEO/PM	Capability	RDT&E/Proc	Lab to Manufacturing	Component	Investment	Commercial
Industrial Base Investment Fund (IBIF)	x	x	x	x	x	x	x	x
Corporate Chairman's Innovation Funds	x	x	x	x	x	x	x	x
Advance Concept Technology Demonstration (ACTD)					X	X	X	
Advanced Technology Demonstration (ATD)						X	X	
Army Rapid Equipping Force (REF)				X	X	X	X	X
Defense Advanced Research Projects Agency (DARPA)	X				X	X	X	
Defense Acquisition Challenge (DAC) Program	X	X		X	X	X	X	
Defense Production Act (DPA) Title III	X		X		X	X	X	
Defense Venture Catalyst Initiative (DeVenCI)	X		X		X	X		X
Foreign Comparative Test (FCT)	X				X	X	X	
CIA's In-Q-Tel						X	X	X
Manufacturing Technology (ManTech) Program	X		X			X	X	
Manufacturing Technical Assist. Production Prgrm. (MTAPP)		X			X	X		
Mentor Protégé	X			X	X	X		
National Technology Alliance/Rosettex				X		X	X	X
Navy Commercial Technology Transition Office (CTTO)		X			X		X	X
Rapid Acquisition Incentive - Net Centricity (RAI-NC) Portal	X		X	X	X		X	X
NSA Corporate Strategy Office						X	X	X
US Army On-Point						X	X	X
Quick Reaction Fund (QRF)	X	X		X	X	X	X	
Small Business Innovation Research (SBIR)						X	X	X
Service Labs						X	X	
SOCOM/Arrowhead	X		X	X	X		X	X
TechConnect						X		
Technology Support Working Group (TSWG)	X				X	X	X	X
Technology Transition Initiative (TTI)	X	X		X	X	X	X	
TechTRANSIT	X					X		
Warfighter Rapid Acquisition Programs (WRAP)					X	X	X	

[1] Program surveyed do not necessarily represent a complete set of all initiatives underway within DoD.

Taxonomy Composition: Characteristics of Selected DoD Technology Development and Transition Initiatives and Functions

Advocacy

The military organization that is the primary driver of a given initiative's funding, priorities or implementation.

Service: Indicates that an individual Service is the primary driver of the given initiative. Some initiatives cover more than one Service in a variety of individual cases, but if the individual cases are service-specific, the initiative is still considered to be single-Service.
Joint/OSD: The priorities and direction of the initiative and driven by a joint organization, or by the Office of the Secretary of Defense.

Customer Orientation

The type of technology community that is the most immediate consumer of the products of a given initiative, and the output that this customer typically expects.

Labs: The government labs that coordinate and execute research and technology development. Labs traditionally produce or expect research results and/or laboratory demonstration articles, rather than products ready for production or application.
User Community: Organizations from the user community, looking for solutions that can be applied directly to warfighting challenges.
Program Managers: Managers of existing programs, looking for technology that can be injected into their programs to improve cost or effectiveness.

Span of Awareness

The segment of the defense landscape in which the initiative searches for both unmet technology requirements, and opportunities for application of existing technology.

Service or Platform: The initiative, or the efforts within the initiative, tend to limit their landscape to the requirements or opportunities of a platform, a platform type, or a single service.
Capabilities: The initiative uses a capability sector, or a general capability class, to define the landscape from which requirements and opportunities are identified and matched.

Funding

Whether the funding for an initiative is from the categories normally directed to Science and Technology (6.1 Basic Research, 6.2 Applied

Research and 6.3 Advanced Technology Development categories) or from the categories directed to transition of technologies to and production of systems.

S & T : Technology Development
6.4+ : Technology Transition and Production

Innovation Portal

The portal in the typical technology development cycle that is targeted by the initiative.

Science and Technology: The initiative deals mostly with the development of technologies that are not ready for transition from the lab to production.
Lab to Manufacturing or Later: The initiative focuses on technologies that are nearly ready for production, and/or insertion into a given acquisition program.

Technology Scope

Does the initiative target technologies that are normally components or subcomponents of a defense system, or does it target technologies that are, or will become systems of themselves?

Function

Is the initiative primarily performing a networking or investment function?

Networking: The primary function of the initiative is to match the creators of technology with the programs or systems that can make use of that technology, or to match private investment capital with the technology that may be useful to the Department.
Investment: The primary function of the initiative is to identify technologies that merit government investment, and then allocate that investment, and monitor the progress of the technology's development.

Primary Marketplace

What type of firms does the initiative target in its search for promising technology?

Military: The initiative most often turns to firms with experience in the creation or production of military technology.
Commercial: The initiative is intended to make use of firms and technology developed primarily in the commercial sector.

Glossary of Selected DoD Technology Development and Transition Initiatives and Functions

Advance Concept Technology Demonstration (ACTD)
Since 1994, ACTDs have served DoD by exploiting mature and maturing technologies to solve important military problems. ACTDs are designed to allow users to gain an understanding of proposed new capabilities for which there is no user experience base. The emphasis in ACTDs is on near-term responses to validated joint military needs.

The Deputy Under Secretary of Defense (Advanced Systems & Concepts) (DUSD/ AS&C) has the oversight responsibility for the ACTD program. She is responsible for developing and promulgating guidance regarding the ACTD program, for evaluating candidates and approving new ACTDs, and for providing oversight, support and evaluation of ongoing ACTDs. The timeframe for completing the evaluation of military utility is typically 2-4 years.

The emphasis in ACTDs is on near-term responses to validated joint military needs. The responses are typically technology based and usually include new operational concepts and, occasionally, new organizational structure.
At the conclusion of the ACTD operational demonstration, there are three potential outcomes. The user sponsor may recommend acquisition of the technology and fielding of the residual capability that remains at the completion of the demonstration phase of the ACTD to provide an interim and limited operational capability. If the capability or system does not demonstrate military utility, the project is terminated or returned to the technology base. A third possibility is that the user's need is fully satisfied by fielding the residual capability that remains at the conclusion of the ACTD, and there is no need to acquire additional units.

Advanced Technology Demonstration (ATD)
ATDs support the Army, the Air Force and the Navy by funding technology demonstrations. Projects typically last five or fewer years and are relatively large scale.

Projects involve operators/users from planning through final documentation to ensure warfighter relevance and buy-in. Testing may occur in a real or synthetic operational environment. Schedules typically span five or fewer years and include cost, schedule, and objective performance baselines. ATDs are run at the Service level and there is no single ATD process.

Army Rapid Equipping Force (REF)
The Army REF, established in 2002, provides operational commanders with rapidly employable solutions to enhance lethality, survivability and force protection through insertion of COTS-GOTS and Future Force technologies while informing Army stakeholders to remain ahead of an adaptive enemy.

With an organization of 40 reporting to the Vice Chief of Staff, Army (VCSA), the Rapid Equipping Force (REF) works directly with operational commanders to find promising materiel solutions to their identified operational requirements. Selected solutions may be off the shelf (either government or commercial) or near-term developmental items that can be available quickly.

Based on the success of those efforts, the Army senior leadership has directed that the REF be expanded and institutionalized as an independent activity taking operational guidance from the G3 and reporting directly to the VCSA. The REF will continue rapidly inserting new technology solutions that address the current battlefield issues of engaged and deploying forces. It will also begin to develop, experiment with and evaluate key technologies and systems for achieving future force capabilities under operational conditions.

Commercial Technology Transition Officer (CTTO) – Venture Initiatives (Office of Naval Research)

After its inception in 2000 and modification in July 2003, CTTO has supported the Navy and Marine Corps. CTTO acts as a matchmaker and technology broker to drive innovative R&D by matching needs with transition-ready technologies. CTTO bridges the POM cycle for closing deals. CTTO also examines various commercial practice business models to adapt the best ones to serve the Navy and Marine Corps' technology needs for commercial technology (Spin-In) and commercialization of Naval intellectual property (IP) (Spin-Out).

The model chosen uses venture capitalists as advisors in lieu of creating a VC Fund. CTTO is the deal broker between innovative technology companies and PEO acquisitions programs. CTTO acts as a Procurement Fulfillment arm for the Navy. CTTO uses VC@sea exercises to gain early technology awareness and commercial industry trends from VCs while giving VCs an understanding of operational issues. CTTO lets contracts using reallocation of existing resources (e.g, TTI, ACTD, SBIR, IRAD, MANTECH, RTT).

CTTO was originally created to accelerate the transition of ONR research technology into acquisitions. In June 2002, in response to HAC Report 107-532, Navy ASN(RDA) and ONR examined commercial VC practices and models and decided that it was not necessary to establish a VC fund to speed technology to Navy programs. Instead the CTTO chose to work with the VC community through a VC panel under the existing NRAC. They are now extending this model in developing relationships for working with innovative technology companies.

The organization consists of 6 deal makers governed by a Venture Capital Executive Steering Group and Venture Capital Advisory Panel under NRAC. It spends $10-15M of Rapid Technology Transition (RTT) funds plus 1% of ASN(RD&A) RDT&E. Deals fall in the range of $1-2M with a project cycle of 1-2

years. Technology areas of interest include IT, advanced microelectronics and photonics, wireless networking, and biotechnology.

Combating Terrorism Technology Task Force (CTTTF)
The Combating Terrorism Technology Task Force (CTTTF) was formed Sept. 19, 2001. Combating Terrorism Technology Task Force (CTTTF) provides a forum to examine the technology alternatives to address immediate operational needs to support the Global War on Terrorism (GWOT). The task force's objective is to rapidly identify, prioritize, integrate and deliver DOD technologies to help fight the war on terrorism.

CTTTF consists of senior S&T executives, as well as senior representatives from CIA, DIA, Homeland Security, Department of Energy, Combatant Commanders and others as needed, and includes representatives from agencies, industry, and academia.

The CTTTF will continue to serve as a conduit for matching the identification of new challenges in the GWOT with available technologies developed both by the DoD, through commercial sources, and with other Departments of the Federal Government.

Defense Advanced Research Projects Agency (DARPA)
Since 1958, DARPA has supported DoD by funding research to gain capabilities that will be needed years in the future. DARPA was established as the first U.S. response to the Soviet launching of Sputnik. Its mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from harming national security by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their military use.

With a staff of over 200, DARPA had very limited overhead and minimal laboratories and facilities. It responds to the Director of Defense Research and Engineering (DDR&E). Projects fall in the range of $10-40 M and typically last 3-5 years with exceptions for major technological challenges. To maintain innovation, program managers remain at DARPA for 3-5 years.

Defense Acquisition Challenge (DAC) Program
Since 2003, the Defense Acquisition Challenge (DAC) Program is one of three components of the Quick Reaction Special Projects (QRSP) portfolio. The Challenge Program was authorized by Title 10, USC, Sec 2359b. DACP provides increased opportunities for the introduction of innovative and cost-saving technologies into DoD acquisition programs.

This program targets primarily industry. It provides opportunities for inserting innovative and cost-saving technology into existing acquisition programs and funds the test and evaluation of proposed technology, not its implementation.

Defense Production Act (DPA) Title III
Since 1950, the Defense Production Act Title III has supported DoD by promoting production capabilities that would otherwise be inadequate to support the material requirements of defense programs in a timely and affordable manner.

The Title III Program is a DoD-wide initiative under the Director of Defense Research and Engineering (DDR&E). Management responsibilities include: program oversight and guidance, strategic planning and legislative proposals, approval of new projects, and liaison with other Federal agencies and Congress.The Air Force serves as the Executive Agent for the Title III Program within the DoD. The Title III Program Office, located at Wright-Patterson AFB, Ohio, is a component of the Manufacturing Technology Division of the Air Force Research Laboratory.

The Program Office identifies and evaluates prospective Title III projects, submits projects for approval by DDR&E, structures approved projects and implements contracting and other business actions relating to projects, oversees active projects, provides for sale and use of materials acquired through Title III contracts, and provides planning and programming support to DDR&E.

Defense Venture Catalyst Initiative (DeVenCI)
Since 2002, DeVenCI has supported OSD and other DoD agencies by leveraging venture capital insight and awareness to provide access to innovative technology companies that traditionally would not do business with DoD. DeVenCI brokers relationships between innovative companies and DoD customers. It goal is to identify and solve short term (e.g., 6 to 18 month) challenges related to the Global War on Terrorism (GWOT) and the security of our Net-Centric Operations (NCO). It provides leadership, policy and coordination for DoD venture activities.

DeVenCI consists of a core project team that: identifies innovative solutions, acts as a broker and catalyst to match user organizations needs to technology solutions to expedite technology insertion. DeVenCI then creates OSD policy and exercises leadership responsibilities to ensure that emerging Defense venture capital initiatives are mutually consistent and reinforcing and by forming a community of interest, developing venture capital activity guidelines, and solving common problems.

Foreign Comparative Test (FCT)
Since 1989, the Foreign Comparative Test (FCT) has consolidated the testing and evaluation of foreign non-developmental items that demonstrate the potential to satisfy user requirements throughout the armed forces. FCT is managed by the DUSD(AS&C). Key program objectives of the Congressionally authorized program include improving warfighting capability, accelerating equipment fielding and saving taxpayer funds.

Test and evaluation are carried out by the sponsoring organization. FCT does not seek to develop technology. Instead, it provides a mechanism to test foreign technology for domestic use.

CIA's In-Q-Tel
In-Q-Tel was the first venture capital initiative created. Since 1999, In-Q-Tel has supported the CIA and NGA. In-Q-Tel is a non-profit venture fund for the discovery, development, delivery and deployment of actionable technologies to enable CIA and IC missions. In-Q-Tel funds product development investments to accelerate technology insertion.

It is a private, non-profit 501c(3) corporation that is autonomous and independent from the government that carries out co-investments with leading venture capitalists and is the sole source with customers. It was established by the CIA with legislative endorsement. The board of directors has committees for: ethics, legal, deal review, strategy and investments, and HR and administration. In addition, the DDS&T provides informal oversight.

In-Q-Tel has a fund of $150M for 5 years. It spends $28-35M annually to fund approximately 20 ideas. The funding of individual projects ranges from $1-3M, where In-Q-Tel is typically a minority investor with a stake of 3-20%. A given project receives funding for 6-24 months. The projects funded are unclassified and of broad capability identified by the In-Q-Tel interface center. Sole source contracts for product development (not procurement fulfillment like CTTO).

In-Q-Tel focuses on 14 areas: application integration, collaboration, search & categorization, data visualization, gaming and simulation, geospatial information services, high speed semiconductors, materials detection, multi/cross-lingual technologies, nanotechnology, power, security and biometrics, sensor, storage, wireless, universal connectivity and communications.

Joint Systems Integration Command (JSIC)
Formerly known as the Joint Battle Center (JBC), the Joint Systems Integration Command (JSIC) is located in Suffolk, Va. and is assigned to the U. S. Joint Forces Command (USJFCOM). The JSIC leads near-term transformation of joint force command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) capabilities through assessing new technology. The JSIC then provides objective recommendations for rapid insertion of solutions to support identified combatant commands' needs for a joint task force (JTF).

Activated on Dec. 17, 1996, the JBC began as a Chairman of the Joint Chiefs of Staff-controlled activity (CCA). In 1998, the JBC was realigned under the then-U.S. Atlantic Command, now U.S. Joint Forces Command. The JBC became the JSIC on September 9, 2004.

The JSIC conducts technology assessments using a recognized and repeatable methodology developed by JSIC personnel. These assessments measure maturity, jointness, and warfighter utility, and are conducted within a three-phase process that includes a study and analysis phase, a laboratory phase, then an operational evaluation phase. The assessments also identify potential costs and impacts on doctrine, organization, training, materiel, leadership, personnel and facilities.

Using the assessment results, the JSIC provides objective recommendations through USJFCOM to the Joint Requirements Oversight Council (JROC) or to other C4ISR program decision makers on the effectiveness and implementation of actual C4ISR systems. This proven and successful process acts as a forcing function for technology insertion of new capabilities.

The JSIC also fosters military service and coalition near-term insertion of technology providing a learning and experimentation environment for warfighters and technologists. Facilitating that are supportive arrangements with service battle labs and activities conducting experimentation and through use of the JSIC's Joint C4ISR Integration Facility and testing laboratory as venues.

The JSIC focuses its effort at the JTF level, ensuring identified capabilities are interoperable from the combatant command level down through the JTF to the component command level. In all cases, the end result is a recommendation that will lead to fielded interoperable capabilities, meeting the joint warfighter's needs as defined through the combatant commands' requirements process, and using C4ISR technological advancements on a near real-time basis.

The JSIC directly supports all the combatant commands by validating current and proposed warfighter C4ISR systems. This process identifies systems that clearly demonstrate joint utility or identifies non-interoperable systems for elimination.

Manufacturing Technology (ManTech) Program

The Manufacturing Technology or ManTech program has supported DoD since 1951 when it began as the Air Force Manufacturing Methods Program. ManTech focuses on the needs of weapon programs for affordable, low-risk production and sustainment capabilities. It matures and validates emerging manufacturing technologies to support low-risk implementation in industry and DoD facilities. Investments are driven by defense-essential needs for: the ability to support 6-sigma (low variability) manufacture, and maturation of process capabilities to acceptable, quantified risk levels; unique production capability; low-cost, high-quality manufacture; efficient factory operations and supplier interaction; decoupling of unit cost from production volume; and efficient maintenance/repair processes and rapid, low-cost spares acquisition.

The primary customers of the ManTech are the acquisition and logistics program managers responsible for transitioning acquisition programs from development into production and for the repair, maintenance, and overhaul of fielded systems. Projects undertaken are beyond the normal risk or interest of industry to pursue in a timely manner. The Program focuses on manufacturing-related needs that are pervasive across industry sectors and throughout the weapon system life-cycle. The primary benefit to the industrial base comes from the emphasis on transfer of the enhanced technologies from the initial demonstration application to the rest of industry. Investments that would benefit a single system are the responsibility of system program managers and are not candidates for ManTech funding.

Manufacturing Technical Assistance Production Program (MTAPP)
Since 1997, the MTAPP has supported the Air Force and the Navy through a training process for small companies to compete for DoD, AF, and Navy projects. The program varies somewhat between Air Force and Navy. It takes small companies and through a three-phase 24 month process to graduate to the level where they can compete. Companies must be at least 2 years old with 10 employees and $ 2 M in sales per year.

The Air Force Office of Small and Disadvantaged Business Utilization established the MTAPP to assist in increasing and enhancing the competitiveness of small manufacturing firms in support of the Air Force, Navy, Department of Defense and their major prime contractors. MTAPP was developed as a five year pilot to assist in increasing the capabilities and enhancing the competitiveness of small business manufacturers in support of the Air Force and the Department of Defense missions.

Mentor Protégé
Since 1990, the Mentor Protégé has provided incentives for (major) DoD prime contractors (Mentors) to help small disadvantaged businesses (SDBs), qualified organizations that employ the severely disabled, and women-owned small businesses (Protégés) develop technical and business capabilities. The goal of the program is to assist protégés to successfully compete for prime contract and subcontract awards. Successful Mentor-Protégé agreements provide a winning relationship for the protégé, the mentor and the DoD. Current participants include companies specializing in environmental remediation, engineering services and information technology, manufacturing, telecommunications, and health care.

NSA
NSA's venture capital arm has issued R&D contracts since December 2003 to support the needs of NSA. NSA's venture capital leverages emerging technology and innovation from the private sector to meet NSA needs. In addition, it expands current Corporate Strategy Outreach initiatives by developing new strategic alliances with industry for national security. Also, it engages the venture capital community in pursuing tech sector analysis/tech scouting and for technology

transfer opportunities. The goal of the projects is the commercialization of NSA intellectual property and leveraging the legacy of NSA's work with industry. Technologies of interest include IA and sensors.

The Corporate Strategy Office reaches out to VCs as an additional source of technology and commercial sector analysis, innovative technology scouting, potential investment mechanism for technology spin out, and building strategic alliances for national security interests. The NSA director is very focused on openness and working with commercial industry.

NSA uses its R&D budget to create Cooperative Research and Development Agreements (CRDAs), Memoranda of Agreement (MOAs), technology transfer agreements, and contract awards. The funding level of awards ranges from almost nil for a technology briefing review up to about $10M for development. Funding can run from 1 day to 5 years on about 20 projects at a time.

US Army OnPoint

OnPoint Technologies is a not for profit organization whose mission is to discover, invest in and support companies and programs developing innovative mobile power and energy technology the commercial market with potential application to U.S. Army needs. OnPoint is funded by the U.S. Army to relieve the Army of the burden of developing certain needed technology solely on its own or through normal procurement.

OnPoint focuses on technologies with the potential to address the requirements of both the individual soldier and the commercial market. These technologies may include anything from long-lasting batteries to novel power-generating devices, including devices for the commercial market, so long as they address Army needs. OnPoint will use a range of investment approaches, including making equity investments, project partnering, research sponsorship, licensing arrangements, and others. OnPoint also acts as a bridge between the Army and the innovation community (entrepreneurs, established companies, universities, researchers, and venture capitalists) to develop business relationships.

OnPoint is focused on discovering, investing in and supporting companies and programs developing innovative mobile power and energy technologies that can be used by the U.S. Army. Technologies of interest include, but are not limited to, devices, systems and software that generate, store, control and manage the power and energy required by individuals for communications, computing, sensing, weapons functioning, mobility and comfort. Parameters of interest for these technologies include low weight and volume, safety, reliability, cost-effectiveness, longevity, reduced system power requirements, and minimal logistics impact.

Quick Reaction Fund (QRF)
The QRF is part of the Quick Reaction Special Projects (QRSP) portfolio and provides flexibility for DoD to respond to emergent needs within budget cycle and to take advantage of technology breakthroughs in rapidly evolving technologies.

QRF requires a deliverable in less than 12 months. It provides an opportunity to execute within the technology cycle in rapidly maturing technologies (e.g., information, electronics, CBD Defense). It provides flexibility to respond to emergent DoD issues and addresses surprises and needs in real time. Technology matures in less than a year in some areas. It responds to technology opportunities in major acquisition programs. QRF program addresses cycle time discontinuity between DoD-programming and execution for rapidly evolving civil sectors.

Rapid Acquisition Incentive – Net Centricity (RAI-NC) Portal
To assist in accelerating transformational efforts, the Deputy Secretary of Defense directed the DoD Chief Information Officer to establish a central investment fund that will encourage DoD Components to accelerate information technology initiatives in support of net centric business transformation.

The RAI-NC effort provides a structured process to select and demonstrate pilot capabilities to support the advancement of Net Centric tenets and transformational processes, field business case based proof of concept projects using commercial off-the-shelf (COTS) and leading edge technology, and provide project results capable of being scaled across the DoD Enterprise.

The vision of RAI-NC is to deliver business case-driven pilot projects and IT initiatives providing scalable proof of concept demonstrations which serve to support transformational, net centric based processes. Its goal is to support the DoD transformation to net centricity by encouraging initiatives focused on DoD enterprise interoperability, enterprise business processes, and enterprise architecture.

The RAI-NC portal is designed to facilitate the acceptance of pilot submissions for the open data call each Fiscal Year of the pilot program and provide instructions and templates to assist submitters throughout the process. Users will also find updated directives, guidelines, and information links that will provide a better understanding of the Net Centric transformation efforts underway within the DoD.

Rosettex
Since February 2002, Rosettex has supported the National Technology Alliance by providing proactive, applied R&D services using "best of breed" companies. Rosettex acts as translator and facilitator between users, solution identifiers, and solution implementers. NTA Executive Board provides guidance and oversight, while Rosettex informal advisory oversight has no separate Board of Trustees. NIMA provides contract management and General Counsel.

Rosettex operates by awarding R&D contracts vehicle with future fund investments. NIMA (the executive agent for the NTA) awarded procurement agreement to advance commercial and dual-use technology innovations to Rosettex Technology and Ventures Group. Seed and early stage investments are made by the For-Profit Rosettex Venture Fund, an Independent LLC.

This model is an outgrowth of the NRO NTA model. Rosettex Technology & Ventures Group is a joint business venture of SRI International and Sarnoff Corporation. Rossetex uses the fees collected at their own discretion and outside of any direct control of the parent company. Project cycles extend to 5 years at Rosettex and 18-24 months at NTA.

Rosettex is a for-profit venture fund with broad life-cycle procurement fulfillment services using capabilities of private companies, academic institutions, systems integrators, market analyst firms, and research orgs to rapidly develop and deploy systems for both military and commercial use. Technology areas of interest include geospatial intelligence; information processing, analysis and management; and digital technology infrastructure

Small Business Innovation Research (SBIR)/Small Business Technology Transfer(STTR)

The Department of Defense (DoD) SBIR and STTR programs fund early-stage R&D projects at small technology companies. These projects serve a DoD need and have commercial applications. Small companies retain the intellectual property rights to technologies they develop under these programs. Funding is awarded competitively under a streamlined process.

The SBIR Program provides funding directly to small technology companies (or individual entrepreneurs who form a company). The STTR Program provides funding directly to small companies working cooperatively with researchers at universities and other research institutions. Fast Track provides a higher chance of SBIR/STTR award, and continuous funding, to small companies that can attract outside investors. For the investors, Fast Track offers an opportunity to obtain a match of between $1 and $4 in DoD SBIR/STTR funds for every $1 the investor puts in.

To participate in the SBIR program: a firm must be a U.S. for-profit small business of 500 or fewer employees; work must be performed in the United States; during Phase I, a minimum of 2/3 of the effort must be performed by the proposing firm; a minimum of 1/2 of the effort in Phase II; the Principal Investigator must spend more than 1/2 of the time employed by the proposing firm.

To participate in the STTR program: a firm must be a U.S. for-profit small business of 500 or fewer employees; there is no size limit on the research

institution; research institution must be a U.S. college or university, FFRDC or non-profit research institution; work must be performed in the United States; the small business must perform a minimum of 40% of the work and the research institution a minimum of 30% of the work in both Phase I and Phase II; the small business must manage and control the STTR funding agreement; the principal investigator may be employed at the small business or research institution.

Funding for SBIR occurs in two phases. Phase I (Project Feasibility) lasts 6 months and costs up to $100k. Phase II (Project Development to Prototype) lasts 2 years and costs up to $750k. Funding for STTR also occurs in two phases. Phase I lasts 12 months and costs up to $100k. Phases II lasts 2 years and costs up to $750k. For SBIR and STTR, commercialization occurs with non-SBIR, non-STTR funds.

SBIR is the largest source of early-stage technology financing in the U.S. Total Federal SBIR/STTR funding in FY 2004 was $2 billion. The DoD accounts for nearly half of the total SBIR/STTR program.

Service Labs

Within DoD, the military service laboratories provide a stable, mission-oriented focus for science and technology, conducting and sponsoring basic (6.1), applied/exploratory development (6.2) and advanced development (6.3) research. These three levels of research are roughly parallel to the military's need to be able to win a current war (through products in advanced development) while concurrently preparing for the next war (with technology "in the works") and the war after next (by taking advantage of ideas emerging from basic research). Past investment in basic research in particular is responsible for the dramatic increases we have seen in our military capabilities.

The present community of DoD in-house laboratories has a rich history, with roots stretching back for more than 150 years. Some of the Navy component activities that make up this community had their roots in legislation passed by Congress in 1841, which first established the Navy bureau system. Over time, the component activities of this community have evolved from small, specialized, laboratories focused on a particular component or weapon to warfare-oriented, Research, Development, Test and Evaluation (RDT&E), technical centers.

SOCOM/ Arrowhead

Since September 2003, SOCOM/Arrowhead has supported SOCOM by establishing commercial contracts to fill technology gaps for system acquisitions. In the future, Arrowhead may also support NORTHCOM.

Arrowhead operates as a non-profit venture fund with a board of directors and panels for ethics and due diligence security (especially for foreign investment) overseeing activities. It seeks a broad array of technologies to support

SOCOM's mission, to include unique weapon systems, sensors and information technologies.

Arrowhead anticipates spending $25M annually for 5 years. It may take equity positions with companies it funds, but it primarily seeks volume purchasing discounts, intellectual property lease, and preferred licensing terms. Funding is expected to be in the range of $250K to $2M with a funding cycle of 4 to 24 months.

Tech Connect
Tech Connect has supported the Air Force since 1993. It is a gateway to provide information on particular technologies, technology searches, and accelerates technology transition and transfer. Users include DoD, other federal agencies, and the private sector. Tech Connect is an Air Force Research Laboratory (AFRL) activity.

Technology Support Working Group (TSWG)
The Technical Support Working Group (TSWG) is the U.S. national forum that identifies, prioritizes, and coordinates interagency and international research and development (R&D) requirements for combating terrorism. The TSWG rapidly develops technologies and equipment to meet the high priority needs of the combating terrorism community, and addresses joint international operational requirements through cooperative R&D with major allies.

Since 1986, the TSWG has pursued combating terrorism technologies in the broad context of national security by providing a cohesive interagency forum to define user based technical requirements spanning the Federal interagency community. By harnessing the creative spirit of U.S. and foreign industry, academic institutions, government, and private laboratories, the TSWG ensures a robust forum for technical solutions to the most pressing counterterrorism requirements. Participants in the ten functional subgroup areas of the TSWG can come to a single table to articulate specific threats and user defined approach to the rapid prototyping and development of combating terrorism devices, training tools, reference materials, software, and other equipment.

The TSWG continues to focus its program development efforts to balance investments across the four pillars of combating terrorism: antiterrorism, counterterrorism, intelligence support and consequence management. TSWG operates under the management and technical oversight of the Department of Defense (DoD) Assistant Secretary of Defense for Special Operations and Low-Intensity Conflict (ASD (SO/LIC)).

Technology Transition Initiative (TTI)
TTI is part of the Quick Reaction Special Projects Portfolio. Its role is to facilitate the rapid transition of new technologies from S&T into acquisition programs. TTI

addresses the funding gaps that exist between the time a technology is demonstrated and the time it is procured for use in an intended weapons system. TTI is intended to accelerate the introduction of new technologies into operational capabilities for the armed forces.

TTI can successfully demonstrate new technologies in relevant environments. The science and technology and acquisition executives of each military department and each appropriate Defense Agency and the commanders of the unified and specified combatant commands nominate projects to be funded. The TTI Program Manager identifies promising projects that meet DoD technology goals and requirements in consultation with the Technology Transition Council. The TTI Program Manager and the appropriate acquisition executive can share the transition cost. Service/Agency contribution can be up to 50% of the total project cost.

To be considered for TTI funding, a project must utilize technology developed with S&T funding, have a buyer with funds available to purchase it in later years, preferably be Joint or Multi-Service project (2 or more Services/Agencies), involve cost sharing between TTI and Service/Agency is encouraged to leverage funding, and have a project duration of less than four years.

TechTRANSIT

TechTRANSIT provides access to Department of Defense technology transfer programs, policies, and resources. It promotes partnering opportunities between the private sector and defense labs, improves accessibility of technology transfer information activities.

Warfighter Rapid Acquisition Program (WRAP)

The WRAP has supported the Air Force since 2000. WRAP is intended for limited number of high value, high leverage initiatives that provide quick solutions to current needs. WRAP is a method to quickly initiate and fund projects that result from spiral development, warfighter experiments, and other sources to improve AF systems and programs.

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APPENDIX G

TECHNOLOGY TRANSITION
POINTS OF CONTACT

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Please contact Stephen Thompson at 703-602-4331 for a full list of contacts.

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Appendix H

Technology Readiness Levels (TRLs)

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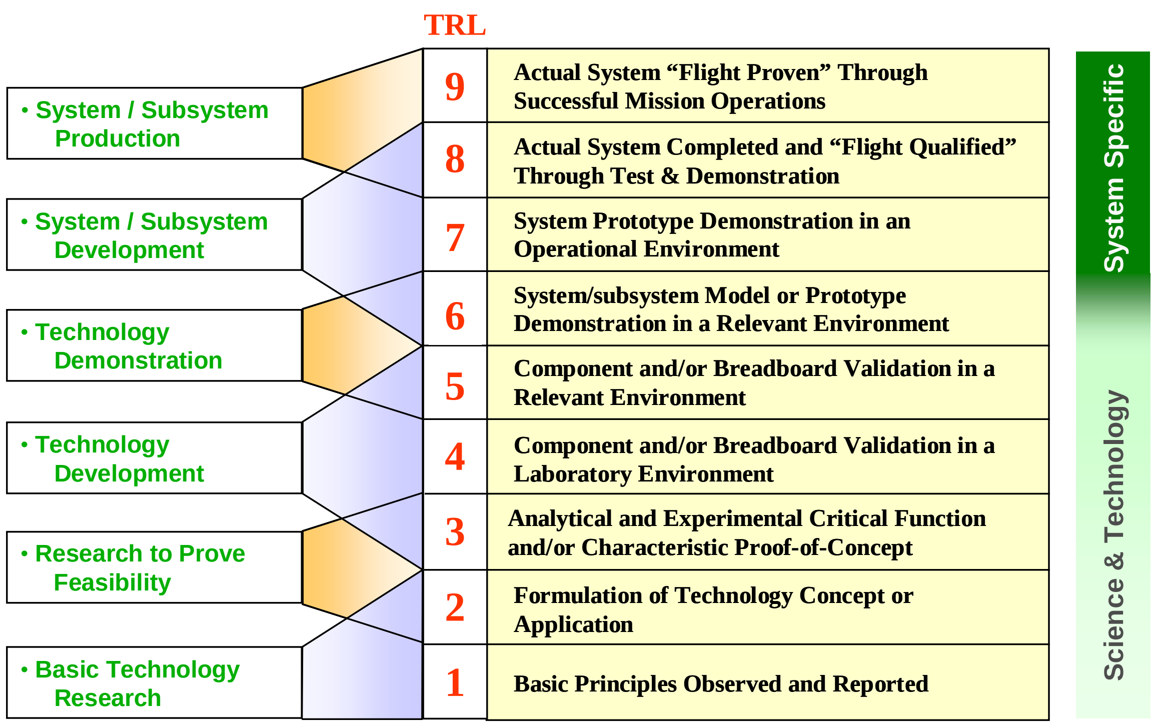
Overview of Technology Readiness Levels

Technology Readiness Levels (TRLs) are a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology.



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APPENDIX I

INDUSTRIAL BASE INVESTMENT FUND APPLICATION FORM

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Defense Industrial Base Investment Fund Application Form

Instructions to applicants. Complete all fields as completely as possible. Submit separate forms for each product/technology. For items 3-6, choose appropriate selection from pull down menus. To make most effective use of this application, it is important to be very familiar with the Defense Industrial Capabilities Studies (DIBCS) which maps discrete enabling technologies to warfighting capabilities within broad functional concepts. Accurate technology/product positioning within this construct is critical for proper assessment, evaluation and screening. For items 4-6, refer to the appropriate DIBCS report appendix for definitions. Submissions are treated as applicant-proprietary by the Department of Defense. Submission assumes endorsement of Chief Technology Officer and Chief Executive Officer.

1 Organization Name/Location:		***2 Organization Type:***	
Include name of holding company/parent organization if applicable. City and state of headquarters and operating location responsible for technology/product (if different)		*Public or private Company, non-profit institution, academic or federal lab, FFRDC, other.*	
3 Organization Description:		***4 Functional Capability:***	
Provide description of your firm/organization to include treatment of your size, experienec and capability, generally, and specifically as it pertains to your submission.		*Must be one of six Joint Staff/DIBCS defined functional architectures to which proposal applies (Battlespace Awareness, Command & Control, Force Application, Protection, Focused Logistics or Network Centric)*	
5 Technology Area:		***6 Warfighting Capability:***	
Specific technology area which is best fit for your technology/product. Technology area selections are defined by selection in block 4. Refer to Appendix B of the corresponding DIBCS report for listing.		*Specific warfighting capability enabled by technology/product. Capability selections are defined by selection in block 5. Refer to Appendix A of the corresponding DIBCS report for listing.*	
7 Total Estimated Cost:		***8 Estimated Time:***	
Include full treatment of NRE and recurring costs. Provide cost analogies as appropriate to reinforce estimates.		*Provide estimate of when first product can be delivered, if applicable, when interim operational capability will occur, and on what platforms.*	

9 Competitive Assessment:

Describe differences between technology/product and most immediate competitor technologies/products and the state-of-the-art. Refer to company compendium of appropriate DIBCS report for list of competitors. Treatment should not be limited to these firms. Write in complete sentences. Limit response to 300 words.

10 Technology Maturity:

Describe the maturity of the technology. Use technology readiness level (TRL) if such an assessment has been done. If not, describe degree to which the technology/product has been demonstrated and is in use, either as part of a fielded system or as a commercial product. Treat risk. Write in complete sentences. Limit response to 300 words.

11 Producability Assessment:

Describe degree to which product/technology is being produced. Include current production volume, location of production facilities and surge capability/capacity with relative timing (i.e. how much time/investment to double production). Treat risk. Write in complete sentences. Limit response to 300 words.

12 Stakeholder Support/Validation:

Provide specific names, positions, organizations and contact information of stakeholders you've contacted with regard to this innovation, the degree and type of support received. Write in complete sentences. Limit response to 300 words.

13 Chief Technology Officer:		***14 Chief Executive Officer:***	
Enter name and contact information to include address, e-mail, phone and fax numbers. Unless otherwise indicated, it is assumed the CTO is the primary point of contact.		*Include name and contact information to include address, e-mail, phone and fax.*	

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